Knowledge & Scientific News

A MONTHLY JOURNAL OF SCIENCE.

Conducted by MAJOR B. BADEN-POWELL, F.R.A.S., and E. S. GREW, M.A.

VOL. III. No. 23. [NEW SERIES.] OCTOBER, 1906. [Entered at Stationers' Hall.] SIXPENCE NET.

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An Interesting New Asteroid.

Approximation of the Mean Distance and Mass of TG.

BY PROF. F. TARRIDA DEL MARMOL, C.E.

TG, the newly-discovered asteroid, is interesting, not only because it widens as far as the limits of the orbit of Jupiter the region of the small planets, but, too, as a confirmation—according to the results of recent observations—of the elegant theorem of Lagrange: "Three celestial bodies, whatever their masses, can move permanently at the angles of an equilateral triangle." Until now no confirmation was found in Nature of that curious dynamical possibility, the verification of which the great French mathematician left to future generations. Now, the Sun, Jupiter, and TG are precisely three bodies which, according to the observations alluded to above, verify the proposition of Lagrange.

The articles by Professor Abetti and by Mr. Crommelin which appeared in the August and September numbers of "KNOWLEDGE" respectively, strongly tend to confirm the above, as does the information published in the July issue; but I wish to remark, with reference to the latter, that there is surely an error in the observations quoted "of April 22nd combined with those of February 22nd and March 23rd, which show a mean distance a little *greater* than that of Jupiter." It is easy to prove that this mean distance is not larger, but rather smaller than that of the giant planet, and it is even possible to fix the limits of that distance and, consequently, obtain an approximation of the mass of TG. By the same process, that approximation will be substituted by an exact calculation when, through observation, the exact distance from the Sun of that asteroid will have been established.

Let d and d' be the respective distances of Jupiter and TG from the Sun, t the time of their revolution, which is identical for both according to observations, M the mass of the Sun, m that of Jupiter, and x that of the asteroid.

According to the Keplerian laws, taking the masses into account:—

$$\frac{d^3 \div t^2}{M+m} = \frac{d'^3 \div t^2}{M+x}$$

Whence $$d^3 (M+x) = d'^3 (M+m)$$

Therefore $$x = \frac{d'^3 M + d'^3 m - d^3 M}{d^3}$$

Or,

$$x = \frac{d'^3}{d^3}(M+m) - M \quad (A)$$

And again,

$$x = M\left(\frac{d'^3}{d^3} - 1\right) + m\,\frac{d'^3}{d^3} \quad (B)$$

The formula (B), since x, the mass of TG, is certainly smaller than m, that of Jupiter, shows that the quantity in parentheses must be negative, *i.e.*, that $\frac{d'^3}{d^3} < 1$,

or $$d'^3 < d^3$$

or $$d' < d.$$

—Q.E.D.

The formula (A) enables us to find limits between which the distance of TG to the Sun is to be fixed. We know that the mass of the asteroid must be greater than nothing and smaller, at least, than the hundredth part of that of Jupiter (or else it would have been seen long ago). We have then the two inequations:

$$\frac{d'^3}{d^3}(M+m) - M > 0 \quad (1)$$

$$\frac{d'^3}{d^3}(M+m) - M < \frac{m}{100} \quad (2)$$

M, m, and d being known, the solution of these inequations gives us the following limits (taking d = 483,000,000 miles):

$$d' > 482{,}855{,}100$$
$$d' < 482{,}879{,}250$$

which are both very near—but inferior—to the distance from Jupiter to the Sun.

As to the mass of TG, it will be possible to find it with all exactitude with the formula (A) when more precise observations will have established exactly the value of d'. Meanwhile, if we take a value comprised between the limits suggested above, rather nearer to the inferior one we find for the relation $\left(\frac{d'}{d}\right)^3$ the value 0·9990618.

The mass, then, of TG would be

$$x = \left(\frac{d'}{d}\right)^3 (M+m) - M = 0{\cdot}9990618 \times 330310 - 330{,}000 = 0{\cdot}103158$$

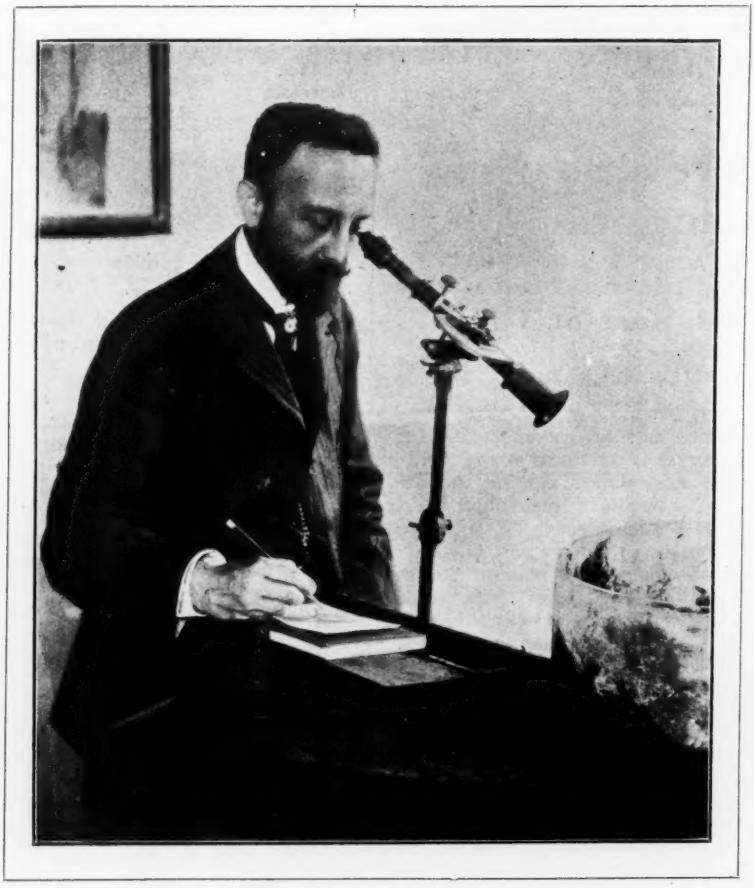
a result which, in my opinion, shows nothing unlikely, although I am, for obvious reasons, inclined to believe that the calculation, when based on strictly exact *data*, will give a figure still smaller.

XUM

The Bioscope or Long-Focus Microscope.

By EMILE GUARINI.

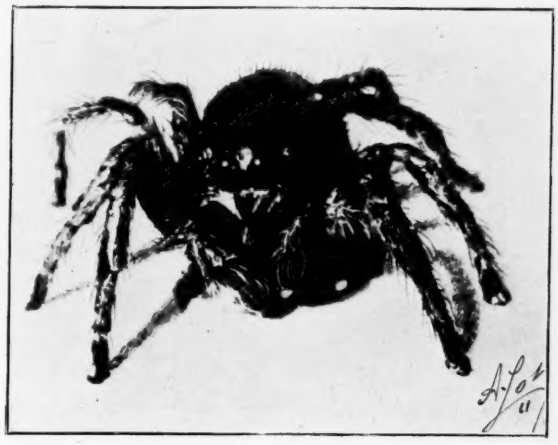
THIS apparatus has recently been devised by M. De Gasparis, of the University of Naples, and constructed by the Contaldi establishment of the same city; it was recently exhibited to the Regio Instituto at Incoraggiamento di Napoli. It is really a very long-focus microscope designed, as its name implies, for the study of the phenomena of animal life in all cases in which it is impossible for the observer to get close enough to the object that he is examining without running the risk of misinterpreting what he sees. It is, indeed, well known that the highly-improved and powerful microscope, to which modern science is indebted for most important discoveries, and the value of which is inestimable in certain domains, is becoming inadequate for the prosecution of some lines of study. It is capable of revealing the inmost structure of minute beings that escape our sight, and of counting the number of cells of which they are composed, but it is almost impossible to observe with it the phases of the normal life of such organisms. How, in fact, can we say that we observe the normal life of an organism when, in order to examine it, we are obliged to bring within a fraction of an inch of such an organism an apparatus that cannot fail to frighten it? In order to observe the normal life of microscopic organisms another instrument is, therefore, necessary, a long-focus microscope capable of being used in cases in which the ordinary instrument becomes inadequate. It is such an instrument that has recently been devised by M. De Gasparis. The apparatus, therefore, permits of obtaining the completest understanding possible of the normal life of insects, of the various manifestations of their intelligence, of their customs and habits, and of their relations with each other and the external world, and cannot fail to give the sciences of observation a new impulse. It has the advantage over the microscope of not necessitating a knowledge of a special technique, delicate and difficult to acquire. In this respect it puts scientific observation within reach of the amateur, who, as there are many examples to prove, is not to be despised. In the field of the bioscope the astonished eye of the observer perceives a new world, a series of scientific surprises. Hatred, anger, joy, and love are depicted in the acts of the infinitely small; the observer distinguishes their weapons and their wounds, and observes their palpitating viscera through their sides, and sees their minute bodies, in the last convulsions of the agony of death, trembling with a final spasm. The



The Bioscope in Use.

struggle for existence among these small organisms takes a character of almost human unsociableness. The smallest animals present themselves in the light of genuine monsters. Their rapid motions, evoked by no external cause, reveal their muscular power. The environment in which they live appears through the apparatus like a landscape with strange and fantastic forms, made attractive by multi-coloured plants of which the transparent structure carries our thoughts into other worlds or toward the remote epochs of the prehistoric ages of our planet. Ants furnish a particularly interesting field for observation, and spiders are no less curious objects for observation. The bioscope is also valuable for scrutinising the life of aquatic animals through the sides of an aquarium, or even in their natural element. It permits of studying bodies submitted to very high temperatures, electric discharges, &c. It may be added that in the domain of medicine it renders possible the observation, under a strong magnification, of dimly-lighted cavities (the larynx, ears, &c.), and of formulating a diagnosis in many cases that have up to the present been doubtful.

How a Fly Looks in the Bioscope.



A Spider at Work.

The apparatus is extremely simple, and is provided with a camera lucida to permit of the drawing of the objects observed. It consists of a tube with a rack provided internally with a system of achromatic objectives perfectly free from spherical aberration, and with a wide field eye-piece. The apparatus is also provided with a system of mensuration and various arrangements for supporting diaphragms. At a distance of 19.9 inches, the bioscope has a magnifying power of more than 12 diameters, say of 144 times the surface.

Spider Attacking the Fly.

The Study of Heredity.

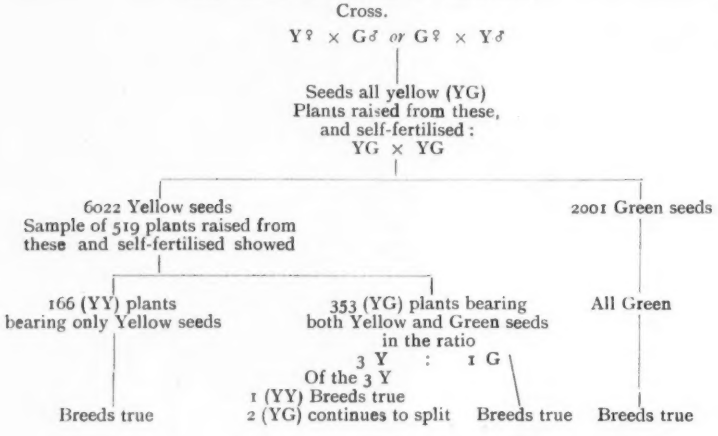
(Continued from page 531.)

The 253 hybrids thus obtained yielded, on self-fertilisation, 8,023 seeds, of which 6,022 were yellow and 2,001 green, the ratio being 3.01 to 1. Plants raised from the green seeds produced only green seeds in subsequent generations; that is, the "extracted recessives" are a pure race identical with the original recessive parental form. From a sample sowing of the yellow seeds Mendel raised 519 plants; of these 166 yielded exclusively yellow seeds, while 353 yielded yellow and green seeds in the proportion of 3 to 1. The former are pure dominants, and continued to breed true; the latter are hybrids of the same nature as those of the first filial generation, and it will be seen that the pure dominants are to the hybrid (apparent dominants) in the proportion of 1 to 2. The latter continue to split in subsequent generations in the proportions of 1 pure yellow : 2 hybrid yellow : 1 pure green; or 1 DD : 2 DR : 1 RR.

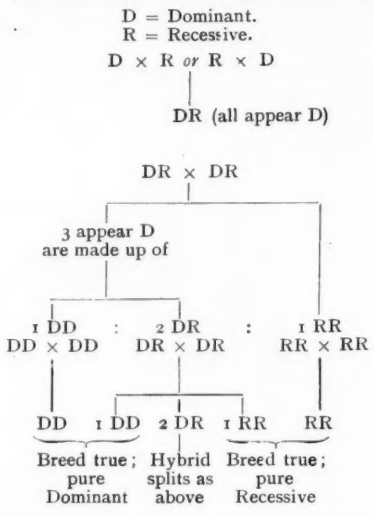
Mendel worked with considerable numbers of individuals, and, although in individual cases, when the numbers are small, the ratios may not be obtained so exactly as in the case cited, yet it is impossible to doubt the general accuracy of the ratios, when an average of the results is taken. The purity of the pure dominants and pure recessives resulting from the self-fertilisation of cross-breds was tested by Mendel in some cases as far as the 6th generation.

To explain these constantly recurring ratios, Mendel suggested that in peas each pure race produces egg

TABLE SHOWING MENDEL'S RESULTS IN THE CROSS BETWEEN PEAS WITH YELLOW AND GREEN COTYLEDONS RESPECTIVELY.


Cross.
Y♀ × G♂ or G♀ × Y♂
Seeds all yellow (YG)
Plants raised from these, and self-fertilised :
YG × YG
6022 Yellow seeds
Sample of 519 plants raised from these and self-fertilised showed
2001 Green seeds
166 (YY) plants bearing only Yellow seeds
353 (YG) plants bearing both Yellow and Green seeds in the ratio
3 Y : 1 G
All Green
Breeds true
Of the 3 Y
1 (YY) Breeds true
2 (YG) continues to split
Breeds true
Breeds true

THE SAME SHOWN IN GENERAL NOTATION.


D = Dominant.
R = Recessive.
D × R or R × D
DR (all appear D)
DR × DR
3 appear D are made up of
1 DD : 2 DR : 1 RR
DD × DD
DR × DR
RR × RR
DD 1 DD 2 DR 1 RR RR
Breed true ; pure Dominant
Hybrid splits as above
Breed true ; pure Recessive

cells and pollen grains all of which carry the character proper to the race. When two opposite characters are brought together in hybridisation, they unite to form the hybrid character, which in the peas so closely resembles one of the parent characters as to be indistinguishable in appearance from it. The hybrid, in its turn, produces pollen grains and egg cells, which are either *pure dominant or pure recessive, and on the average, equal numbers of each kind are produced.* Each cross-bred is then producing gametes in the proportion of :—

♀ 50% pure Dominant.
50% pure Recessive.

♂ 50% pure Dominant.
50% pure Recessive.

In self-fertilisation, random mating between these male and female cells would give :—

$$25\,(D^{\varphi} \times D^{\sigma});\ 25\,(D^{\varphi} \times R^{\sigma});$$
$$25\,(R^{\varphi} \times D^{\sigma});\ 25\,(R^{\varphi} \times R^{\sigma});$$

D × R does not differ from R × D ; we have therefore

$$25\,(D \times D);\ 50\,(D \times R);\ 25\,(R \times R).$$

And since cross-breds resemble dominants in appearance, the apparent result of the cross (DR × DR) is

$$3D : 1R.$$

Mendel next turned his attention to the crossing of races differing from one another in respect of more than one pair of characters. Suppose a race with round seeds and yellow cotyledons be crossed with one which has wrinkled seeds and green cotyledons. Mendel found the round and yellow characters to be dominant respectively over wrinkled and green. We therefore expect the first hybrid seeds to be all round and yellow, a result which Mendel actually obtained. The reproductive cells produced by these hybrids carry either the round *or* wrinkled, and either the yellow *or* green character, the possible combinations being :—

♀ RY	♀ RG	♀ WY	♀ WG
♂ RY	♂ RG	♂ WY	♂ WG

Mendel's hypothesis supposed that, on the average, equal numbers of these different kinds of reproductive cells (gametes) are produced. In self-fertilisation, therefore, random mating would give the following unions and their reciprocals, all occurring in equal numbers :—

♀ RY : ♂ RY	♀ RG : ♂ RG	♀ WY : ♂ WY	♀ WG : ♂ WG
RY : RG	RG : WG	WY : WG	
RY : WY	WG : RG	WG : WY	
RY : WG			
RG : RY			
RG : WY			
WY : RY			
WY : RG			
WG : RY			
9	3	3	1

In the first column are placed all those unions to which the dominant characters, round and yellow, are contributed at least by one of the parents; the plants resulting from these unions are, to the eye, indistinguishable from the pure dominants; in the second and third columns are placed those unions in which the dominant of one pair and the recessive of the other pair of characters is present; while the fourth column contains that union alone in which both pairs of characters are represented only by the recessive member. The offspring should, therefore, appear in the ratio of

$$9RY : 3RG : 3WY : 1WG.$$

a result to which Mendel's figures of

$$315RY : 108RG : 101WY : 32WG.$$

approximate so closely as to be well within the limits of experimental error.

The experimental results related above provide a simple illustration of the principles upon which the Mendelian theory of heredity is based. It would serve little purpose to recount here the numerous confirmatory experiments in the breeding both of animals and plants which have been carried out even in the short time which has elapsed since the rediscovery of Mendel's memoir.

Mendel specifically applied his hypothesis to explain the behaviour of certain characters in peas, without claiming to have discovered a universally applicable law. Widespread as the phenomena of dominance and

segregation* have since been found to be, it must not be supposed that they are universal. Already one or two cases are known in which a more complex form of segregation takes place, which seems to point to a *resolution* of compound characters introduced by the parents into a series of characters which, perhaps, may be susceptible of recombination, by means of suitable matings, into the original compound character.†

Nor does dominance occur universally. Speaking generally, the union of gametes bearing the different members of a pair of characters results in the formation of a hybrid whose character may be:—

(1) Indistinguishable from that of one of the parents.
(2) Intermediate between the characters of the parents.
(3) Unlike either of the characters of the parent.

The first result is that of simple dominance; in the second and third dominance is absent. When a hybrid of either of the last two types is self-fertilised, we are able to distinguish the offspring which result from the union of unlike gametes from the remainder, and thus the ratio of

1DD: 2DR: 1RR

among these offspring is at once appreciable (compare table p. 554). Finally, cases are known in which dominance is irregular, the offspring sometimes resembling one parent, sometimes the other. What determines the dominance in such cases is quite unknown, and it will be seen at once that the work is attended with great difficulty owing to the impossibility of recognising the constitution of any individual from its appearance.

In conclusion, attention must be drawn to the close parallel which exists, as Bateson pointed out in 1894, between the phenomenon of discontinuous variation and that of sex. There follows at once the question as to whether the sex-characters may not undergo segregation in the formation of the gametes of the male, or female, or both. A crucial experiment is still wanting, but indirect evidence is accumulating which steadily points toward an affirmative answer to the question.

It is not possible to go further into detail in this paper; enough has, I think, been said to indicate the principles of the Mendelian method. The offspring of each individual is treated separately, nor does one assume that any two individuals of like descent are similarly constituted until the analysis, carried out by the experiment of breeding from them, has proved them to be so. That is to say, it is not simply through a knowledge of the ancestry of an individual that we can certainly determine its nature, but by a knowledge of its posterity.

R.P.G.

* The production by the cross-bred of gametes pure in respect of one or other member of each pair of characters.

† Since the above was written it has been found that some, at any rate, of the cases referred to here are examples of a phenomenon of great interest. It is now clear that what appears to be a third distinct form may be due to the presence simultaneously of certain members of two definite allelomorphic pairs. For instance, in *Primula sinensis* a strain is known which is characterised by the extensive spreading of the central yellow eye. All these "yellow flush" plants are in the condition called by Darwin "equal-styled." Experiment shows that the yellow flush is an ordinary recessive character, the common non-flushed type being dominant. The flush is transmitted independently of the length of style, and may be transferred to the short-styled or thrum type. Yet when the flush is developed in plants which by gametic composition would be long-styled, the style does not pass through the anthers, and the equal-styled form is produced.

The International Conference on Hybridization and Plant-breeding.

The organisers of the third International Conference on Hybridization, held at Westminster under the auspices of the Royal Horticultural Society, must be heartily congratulated on the great success which attended the meeting. It was a fortunate circumstance that so many distinguished foreign guests were able to accept the Society's invitation, so that the scientific and practical workers of this country had the pleasure of welcoming representatives from Denmark, Germany, Austria, and France, as well as from the United States and Canada.

Since the first Conference was held at Chiswick in 1898, almost revolutionary advances have been made in the study of heredity and variation. It is difficult to realise that only six years ago Mendel's work was still buried in the obscurity where it had lain for 35 years. The scarcely less important discoveries of de Vries, on the origin of species by Mutation, are of still more recent date. No better instances can be cited than those of the successful unravelling of problems in heredity and variation by means of the exhaustive study of a special case. In this method lies the key to the progress which has been made, and to the solution of further problems in the future.

In opening the proceedings of the Conference the President, Mr. Bateson, contrasted the present state of our knowledge of heredity with that which obtained at the first Conference eight years ago. At that time the predominant note was mystery; now we speak less of mystery and more of order; systematic research has now replaced work that could only be carried on in the dark, along ill-defined lines. Mr. Bateson proceeded briefly to discuss some of the practical and theoretical results of the Mendelian laws. He showed that we have now a clear conception of the meaning of "pure-bred," a pure-bred individual being one which develops from the union of two cells, male and female, which are alike in composition, in that they bear identical characters. In the same way Reversion may be explained as the meeting once more of characters long separated, and, conversely, Variation is often the visible sign of separation, or segregation into different germ cells, and thence into different individuals, of characters which have hitherto been known only in combination with one another. The discoveries of Mendel have made it possible to subject the work of the hybridist to precise investigation, and often suggest the course which should be pursued in the attempt to create and fix desirable types, a course which is not always, by any means, that which unaided common sense might suggest. The great advances in the application of science to practical use have generally become possible through discoveries made in the pursuit of knowledge as an end in itself, without ulterior purpose, and it is to work carried on in this spirit that we should look for future results.

Of the numerous papers which were read before the Conference, one of the most interesting was that in which Miss Saunders described her experiments upon Stocks (Matthiola). The flower-colour in Stocks, as in Sweet Peas, has been found to depend upon the simultaneous presence in one individual of two

elements belonging to independent allelomorphic pairs. If the reader will turn to page 556 of the current number he will see that, representing the presence of these elements by the letters A and B, and their absence by a and b, out of 16 individuals there will be on the average nine possessing both factors, and seven having only one or neither of them. That is to say, the ratio of coloured to white-flowered offspring will be as 9 : 7. The coloured plants, moreover, are found to consist of two main classes, purples and red, which occur in the ratio of 3 : 1, thus demonstrating the existence of a third allelomorphic pair, the presence or absence of a blue factor, which, however, can only produce a perceptible effect when the characters A and B are also present. In the 10-week Stocks the problem is further complicated by the fact that the hoariness of the leaves is found similarly to depend upon the presence of two independent factors; not only so, but, in general, this hoariness is only produced if the colour factors also be present! This discovery of the fact that two, and possibly more, independent allelomorphic pairs may enter into the composition of an apparently simple character, is of far-reaching importance in affording an explanation of many results which have hitherto appeared quite irregular and even contradictory.

Mr. Biffen gave an account of some experiments upon breeding of wheat, which must lead to results of supreme practical, as well as theoretical, value. The loss which is entailed every year to wheat crops through the attacks of rust is only too well known. Occasionally, however, there are found plants which show themselves to be immune from the attacks of the fungus. Mr. Biffen has shown beyond any question that this immunity is a transmissible character, inherited according to simple Mendelian principles. The raising of crops immune from rust should, therefore, be only a matter of time. It is not necessary to dwell on the immediate practical value to agriculture of this result; further, it opens a wide field for experiment as to the inheritance of physiological (as distinct from morphological) characters in general, and gives hope of the possibility of producing, by appropriate breeding, in other plants and animals strains immune from certain diseases.

Dr. Rosenberg, of Stockholm, furnished a most interesting paper upon the behaviour of the chromosomes in the formation of the germ cells in hybrid plants. Although much yet remains to be done, and our present evidence is largely indirect, we may look forward confidently to the day when cytological work will give us the key to what we may call the mechanism by which segregation of characters in the germ cells is brought about.

Want of space compels us to omit all mention of many other contributions both of scientific and of practical value, of which full reports will be published in the Royal Horticultural Society's Journal. The heartiest thanks of those who had the privilege of attending the Conference are due to the Royal Horticultural Society and to its members for the generous hospitality which was provided for all. One cannot appreciate too highly the opportunity which the Conference has afforded of meeting those who are working in other countries; of equal value, too, is the recognition given at the Conference to the importance of combined effort between scientific investigators and practical horticulturists; each can provide just that knowledge which is apt to be lacking in the other, and so assist the advance along their respective paths.

Stellar Distances.

By T. E. HEATH, F.R.A.S.

THE list of stars here given, with their magnitudes, spectra, distances in light-years, hypothetical diameters in miles, and sun-power, is taken from my last work, "Stereoscopic Star Charts and Spectroscopic Key Maps," in which the authorities are given. I have added four stars collected from measurements by Prof. Pritchard. As my object was to show all the stars to the fifth magnitude in space of three dimensions, and as I had to use estimated average distances according to magnitude and spectrum for the stars for which I could obtain no measured parallax, I naturally collected all I could. If I believed the distances to be very good, I marked them **, good *, very doubtful ?. I have here grouped the stars according to magnitude and worked out the average distance and sun-power for each magnitude, although beyond magnitude 1·5 the parallaxes measured are too few to make the averages useful. Naturally the nearest stars only have been measured where the magnitudes are small. The hypothetical diameters in miles are calculated upon the supposition that the sun and stars, for equal surfaces, give equal light, and, though this is certainly not true, form a foundation upon which we can build ideas as to size which will be greatly modified by the spectra and temperature of the stars as compared with the sun. I have assumed the sun's magnitude is −26·5. Readers of my first article in "KNOWLEDGE" will recollect my scale for stellar distances. If the distance of the earth from the sun be represented by one inch, then one light-year will be represented by one mile, and the distance to the furthest known planet by one pace of 30 inches. So to journey mentally to Sirius you think of walking 8⅔ miles with strides sufficient at each pace to carry you to Neptune.

I give the mass in a few cases. It is evident in some cases, as the bright star of Sirius and Algol, the density is far less than the sun's; but with the darker star of Sirius and of 85 Pegasi, it is much greater.

MAGNITUDE −1·58 TO −0·50.

R. A. H. M.	Decl. ° ′		Mag.	Spect.	Light Years.	Hyp. Dia.	Sun Power.	Mass.
6 21.7	− 53 38	α Carinæ ..	−0·86	F	? 543	219,000,000	63,756·0	
6 40.7	− 16 35	α Canis Majoris	−1·58	A	** 8·64	4,980,000	32·72	3·5
		2 Stars average			275·8		31,894	

MAGNITUDE −0·49 TO + 0·50.

R. A. H. M.	Decl. ° ′		Mag.	Spect.	Light Years.	Hyp. Dia.	Sun Power.	Mass.
5 9.3	+ 45 54	α Aurigæ ..	+ 0·21	G	** 37·4	9,450,000	117	18·4
5 9.7	− 8 19	β Orionis ..	+ 0·34	B8A	? 543	128,600,000	21,609	
5 49.8	+ 7 23	α Orionis ..	+ 0·31 / 0·94	Ma	112	26,770,000	952	
7 34.1	+ 5 29	α Canis Minoris	+ 0·48	F5G	** 9·55	2,123,000	6	3·63
14 11.1	+ 19 42	α Boötes ..	+ 0·24	K	*95·8	23,740,000	825	
14 32.8	− 60 25	α Centauri	+ 0·36 / + 1·67	G / K5M	**4·30	1,013,800 / 554,000	1·37 / 0·40	2·0
18 33.6	+ 38 41	α Lyræ ..	+ 0·14	A	**36·6	9,445,000	119	
		7 Stars average			119·8		3361	

MAGNITUDE 0·51 TO 1·50.

R. A. H. M.	Decl. ° ′		Mag.	Spect.	Light Years.	Hyp. Dia.	Sun. Power.
1 34.0	− 57 45	α Eridani ..	0·60	B5A	* 69·3	14,700,000	289
4 30.2	+ 16 19	α Tauri ..	1·06	K5M	** 28·1	4,680,000	29·2
7 39.2	+ 28 16	β Geminorum ..	1·21	K	* 49·3	7,620,000	77
10 3.0	+ 12 27	α Leonis ..	1·34	B8A	* 105	15,600,000	324
12 21.0	− 62 33	α Crucis ..	1·05	B1A	* 66·3	11,260,000	169
12 41.9	− 59 9	β Crucis ..	1·50	B1A	? 362	49,500,000	3271
13 19.9	− 10 38	α Virginus ..	1·21	B2A	? 217	33,620,000	1505
13 56.8	− 59 33	β Centauri ..	0·86	B1A	* 90·5	16,670,000	370
16 23.3	− 26 13	α Scorpii ..	1·22	MA	* 121	18,700,000	467
19 45.9	+ 8 35	α Aquilæ ..	0·89	A5F	** 13·6	2,470,000	8·12
20 38.0	+ 44 55	α Cygni ..	1·33	A2F	?? 465	68,460,000	6241
22 52.1	− 30 9	α Piscis Aust. ..	1·29	A2F	** 249	3,750,000	18·7
		12 Stars average			124·6		1064

MAGNITUDE 1·51 TO 2·50.

R. A. H. M.	Decl. ° ′		Mag.	Spect.	Light Years.	Hyp. Dia.	Sun Power.	Mass.
0 3.2	+ 28	32 α Andromedæ	2·15	A	55·2	5,630,000	42	
0 3.8	+ 58	36 β Cassiopeiæ..	2·42	F5G	** 32·6	3,000,000	11·5	
0 34.8	+ 55	59 α Cassiopeiæ..	2·47	K	90·5	8,030,000	87	
0 50.7	+ 60	11 γ Cassiopeiæ..	2·25	B	? 460·0	45,200,000	2725	
1 4.1	+ 35	5 β Andromedæ	2·37	Ma	35·4	3,260,000	14·2	
1 22.6	+ 88	46 α Ursæ Minoris	2·12	F8G	44	4,530,000	27·5	
2 1.5	+ 22	59 α Arietis ..	2·23	K2M	40·7	4,000,000	21·3	
3 1.0	+ 40	34 β Persei ..	2·31	B8A	93	8,750,000	102	0·67
3 17.2	+ 49	30 α Persei ..	1·90	F5G	44	5,110,000	35	
5 20.0	+ 28	31 β Tauri ..	1·78	B8A	51·7	6,200,000	51	
5 52.2	+ 44	56 β Aurigæ ..	2·07	A Pec	54·3	5,630,000	42	
7 28.2	+ 32	6 α Geminorum	1·58	A	? 16·4	2,160,000	6·25	
10 14.5	+ 20	21 γ Leonis ..	2·30	K	165	13,900,000	259	
10 58.8	+ 56	55 β Ursæ Majoris	2·44	A	197	17,300,000	400	
10 57.6	+ 62	17 α Ursæ Majoris	1·95	K	70·7	7,800,000	81	
11 44.0	+ 15	β Leonis ..	2·23	A2F	112	11,000,000	162	
12 49.6	+ 56	30 ε Ursæ Majoris	1·68	A	197	24,740,000	815	
13 19.9	+ 55	27 ζ Ursæ Majoris	2·09	A	197	20,530,000	562	
13 43.6	+ 49	49 η Ursæ Majoris	1·91	B3A	? 24·3	3,900,000	20·25	
14 51.0	+ 74	34 β Ursæ Minoris	2·24	K5M	148	14,700,000	289	
17 54.3	+ 51	30 γ Draconis ..	2·42	K5M	65·2	5,640,000	43	
20 18.6	+ 39	56 γ Cygni ..	2·32	F8G	31·9	3,039,000	12·3	
22 1.9	− 47	27 α Gruis ..	2·16	B5A	**148	15,079,000	303	
		23 Stars average			101·8		268	

MAGNITUDE 2·51 TO 3·50.

R. A. H. M.	Decl. ° ′		Mag.	Spect.	Light Years.	Hyp. Dia.	Sun Power.	Mass.
0 20.5	− 77	49 β Hydri ..	2·90	G	**22·5	1,610,000	3·45	
8 52.5	+ 48	26 ι Ursæ Majoris	3·12	A5F	25	1,655,000	3·6	
9 26.2	+ 58	2 θ Ursæ Majoris	3·26	F8G	70·9	4,330,000	25	
11 48.6	+ 54	15 γ Ursæ Majoris	2·54	A	** 197	16,700,000	372	
12 10.5	+ 57	35 δ Ursæ Majoris	3·44	A2F	197	11,000,000	161	
12 36.6	− 0	54 γ Virginis	2·91	F	** 44	3,155,000	13·25	3·3
16 37.5	+ 31	47 ζ Herculis ..	3·00	G	23·3	1,550,000	3·21	
			3·1					
17 10.1	+ 14	30 α Herculis ..	3·9	Mb	65·2	4,330,000	25	
17 10.9	+ 24	57 δ Herculis ..	3·16	A	65·2	4,330,000	25	
17 11.6	+ 36	55 π Herculis ..	3·36	K2M	29·6	1,730,000	4	
20 42.2	+ 33	36 ε Cygni	2·64	K	28·3	2,250,000	6·76	
21 39.3	+ 9	25 ε Pegasi.. ..	2·54	K	40·7	3,520 000	16·5	
21 16.2	+ 62	10 α Cephei ..	2·60	A2F	53·4	4,640,000	25·8	
22 59.8	+ 14	40 α Pegasi ..	2·57	A	40·2	3,470,000	16	
		14 Stars average			64·4		50	

MAGNITUDE 3·51 TO 4·50.

R. A. H. M.	Decl. ° ′		Mag.	Spect.	Light Years.	Hyp. Dia.	Sun Power.	Mass.
0 14.9	− 65	28 ζ Toucanæ ..	4·34	F8G	** 20	730,000	0·70	
0 43.0	+ 57	17 η Cassiopeiæ ..	3·64	F8G	** 21·1	1,080,000	1·56	1·62
1 39.4	− 16	28 τ Ceti	3·65	G	** 11	567,000	0·42	
3 15.9	− 43	27 e Eridani.. ..	4·30	G5K	20·3	762,000	0·79	
3 28.2	− 9	48 ε Eridani ..	3·81	K	?? 17·7	832,000	0·92	
4 10.7	− 7	48 O² Eridani ..	4·48	H	** 15·8	537,000	0·39	
6 9.0	+ 44	56 κ Aurigæ ..	4·45	K	65·2	2,250,000	6·76	
			4·1	Pec				
7 55.4	− 49	58 V Puppis.. ..	4·8	B1A	1810·	74,400,0000	7361·	
8 54.2	+ 42	11 10 Ur. Majoris ..	4·09	F5G	* 16·3	676,000	0·61	
13 7.2	+ 28	23 β Comæ Ber. ..	4·32	G	29·3	1,490,000	1·59	
13 21.2	+ 55	30 g Ursæ Majoris	4·02	A2F	197	7,800,000	81·	
14 1.7	+ 64	51 α Draconis ..	3·74	A	13	667,000	0·58	
16 39.5	+ 39	7 η Hercules ..	3·61	K	8·14	493,000	0·5	
18 0.4	+ 2	31 70 Ophiuchi ..	4 07	K	** 20·1	830,000	0·92	2·9
18 4.5	+ 86	37 δ Ursæ Minoris ..	4·44	A	108·6	3,720,000	18·5	
18 41.4	+ 20	27 110 Hercules ..	4·26	F	81·4	3,030,000	12·2	
21 40.1	+ 25	11 κ Pegasi	4·27	F5G	30·7	1,157,000	1·57	
		17 Stars average			146		440	

MAGNITUDE 4·51 TO 5·50.

R. A. H. M.	Decl. ° ′		Mag.	Spect.	Light Years.	Hyp. Dia.	Sun Power.	Mass
1 1.2	+ 54	27 μ Cassiopeiæ ..	5·34	H	29·6	698,000	0·64	
4 1.9	+ 37	47 50 Persei ..	5·5		81·4	1,780,000	4·25	
6 39.5	+ 43	51 ψ ⁵Aurigæ ..	5·3		29·6	745,000	0·74	
6 53.7	+ 87	12 51 H Cephei	5·2		120·7	3,040,000	12·3	
7 41.9	− 33	59 Lac 2957 ...	5·42		** 33·9	770,000	0·79	
9 55.2	+ 32	25 20 Leo Min. ..	5·5		54·3	1,190,000	1·88	
17 30.2	+ 55	14 ν ¹Draconis ..	4·98	A	* 10·1	277,000	0·102	
19 20.2	+ 11	44 31 Aquilæ ..	5·3		47·9	1,140,000	1·57	
19 32.6	+ 69	29 σ Draconis ..	4·78	K	12·4	372,600	0·185	
21 21	+ 38	17 61 Cygni ..	4·96	H	** 10·0	268,000	0·102	
21 9.6	+ 9	36 δ Equulei ..	4·61	F	** 45·7	1,480,000	2·92	1·89
21 55.7	− 57	12 ε Indi	4·74	K5M	** 11·1	346,000	0·16	
		12 Stars average			40·56		2·136	

MAGNITUDE 5·51 TO 6·50.

R. A. H. M.	Decl. ° ′		Mag.	Spect.	Light Years.	Hyp. Dia.	Sun Power.	Mass.
11 29.6	− 32	18 Brad 1584.. ..	6·0		108·6	1,870,000	4·67	
11 33.5	+ 45	40 Σ 1561	6·3		108·6	1,600,000	3·42	
11 47.2	+ 38	26 Gr 1880	6·47		*** 21·7	303,000	0·122	
12 10.0	− 9	43 Ll 22954	6·05	E	* 23·3	400,000	0·207	
14 51.6	− 20	57 P XIV hr 212 ..	6·08	H	** 19·0	312,000	0·11	
20 56.6	+ 39	51 Gr 8357	6·00		46·5	784,000	0·81	
23 8.5	+ 56	37 Brad 3077.. ..	5·6		21·7	459,000	0·27	
23 57	+ 26	33 85 Pegasi.. ..	5·83	E	60·3	1,135,000	1·72	11·3
		8 Stars average			51·2		1·416	

MAGNITUDE 6·51 TO 7·50.

R. A. H. M.	Decl. ° ′		Mag.	Spect.	Light Years.	Hyp. Dia.	Sun Power.
9 7.7	+ 53	7 Ll 18115	7·5	H	* 23·3	200,000	0·054
10 5.3	+ 48	58 Gr 1618 or OA 10603 ..	6·76	H	18·1	225,000	0·067
10 21.9	+ 49	21 Gr 1646	6·54	A	29·6	400,000	0·213
11 8.6	+ 74	4 Σ 1516	7·0		30·4	346,000	0·160
11 8.6	+ 74	1 Fed 1831	7·2		14·8	147,000	0·029
12 4.6	+ 41	51 Ll 22810	7·5		48·5	420,000	0·235
12 4.6	+ 40	4 Gr 1835..	7·4		54·3	509,000	0·325
22 59.4	− 36	36 Lac 9352	7·1		** 10·8	112,260	0·071
		8 Stars average			28·7		0·137

MAGNITUDE, 7·51 TO 8·50.

R. A. H. M.	Decl. ° ′		Mag.	Spect.	Light Years.	Hyp. Dia.	Sun Power.
0 12.7	+ 43	27 Gr. 34	7·9		*10·6	75,000	0·008
5 7.7	− 45	3 CZ Vh 243	8·5		**10·2	53,700	0 004
7 47.2	+ 30	52 Ll 15290	8·2		163·0	1,030,000	1·440
9 7.0	+ 53	7 Fed 1457	8·0		14·1	97,000	0 0125
			8·0		15·1	104,000	0·0144
9 37.1	+ 43	10 Ll 19022	8·0		54·3	340,000	0·1857
10 27.7	+ 49	42 Gr 1657	7·6		67·8	560,000	0·400
10 38.0	+ 47	7 Ll 20674	7·9		326·0	2,240,000	7·300
10 57.9	+ 36	38 Ll 21185	7·6		**9·8	78,0.0	0·008
11 0.5	+ 44	2 Ll 21258	8·5		**13 6	72,000	0·007
11 40.3	+ 48	14 Gr 1822	7·7		163·0	1,300,000	2·200
14 52.3	+ 54	4 Fed 2544 or Ll 27298	7·7		37·0	2 0,000	0·110
18 4.1	+ 59	27 Σ 2298	8 2		9·2	60,000	0·005
		13 Stars average			68·7		0·9026

MAGNITUDE 8·51 TO 11.

R. A. H. M.	Decl. ° ′		Mag.	Spect.	Light Years.	Hyp. Dia.	Sun Power.
11 14.8	+ 66	22 OA 11677 ..	9·0		12·0	52,000	0·0040
17 37.0	+ 68	26 OA 17417 ..	9·0		*13·0	59,000	0·0046
18 41.7	+ 59	29 Σ 2398 ..	8·5		*10·93	60,000	0·0050
			9·3		*11·30	21,600	0·0025
22 24.0	+ 57	10 Krueger 60 ..	9·0		** 12·0	31,000	0·0036
			11·0		12·0	5,200	0·0006
		6 Stars average			11·57		0·0034

Summary			Light Years.		Sun Power.
Mag. − 1·58 to M g. − 0·50	2 stars average		275·8	..	31,894
,, − 0·49 ,, ,, + 0·50	7 ,, ,,		119·8	..	3,861
,, + 0·51 ,, ,, + 1·50	12 ,, ,,		134·6	..	1,064
,, + 1·51 ,, ,, + 2·50	23 ,, ,,		101·8	..	268·
,, + 2·51 ,, ,, + 3·50	14 ,, ,,		64·4	..	50
,, + 3·51 ,, ,, + 4·50	17 ,, ,,		146·6	..	440
,, + 4·51 ,, ,, + 5·50	12 ,, ,,		40·5	..	2·135
,, + 5·51 ,, ,, + 6·50	8 ,, ,,		51·2	..	1·416
,, + 6·51 ,, ,, + 7·50	8 ,, ,,		28·7	..	0·137
,, + 7·51 ,, ,, + 8·50	13 ,, ,,		68·7	..	0·902
,, + 8·51 ,, ,, + 11·0	6 ,, ,,		11·0	..	0·0034
	122 Stars				

Answers to Correspondents.

An Old Subscriber.—We propose very shortly to continue the series of Star Maps, but we have been having considerable trouble in getting a really satisfactory means of reproducing them. The De Forest system of Wireless Telegraphy was described in "THE ILLUSTRATED SCIENTIFIC NEWS" for July, 1903. It differs from the Marconi in the sending apparatus, in which no interrupters or coils are employed but an ordinary alternating current, and in the receiving apparatus which is dependent on an electrolytic principle for its action.

Reading.—The primitive barometer described, namely a long-necked flask inverted in a jar of water, is an instrument with which we cannot claim any experience. Theoretically, however, it should act on the same principle as an ordinary mercury barometer, that is, when the pressure of the atmosphere increases, the water should be pressed up the neck of the bottle. But with such an apparatus many other factors have to be considered, one of the chief being the temperature, both of the outside air and the air and water contained in the bottle. The evaporation of the water must also be taken into account.

C.E.C.—The Harvest Moon is the name popularly given to the full moon in September. At this period the moon rises for several evenings running at about the same hour, because its gradual northward movement compensates for its retardation in rising. This is supposed to favour the gathering of the harvest.

T.G.—Amber containing insects is often to be bought from naturalists or from tobacconists (who keep it as a curiosity). But it seems that it is not regularly supplied by either, being so seldom in demand. Tanks for aquaria are to be obtained from Messrs. Watkins and Doncaster, 36, Strand, W.C.

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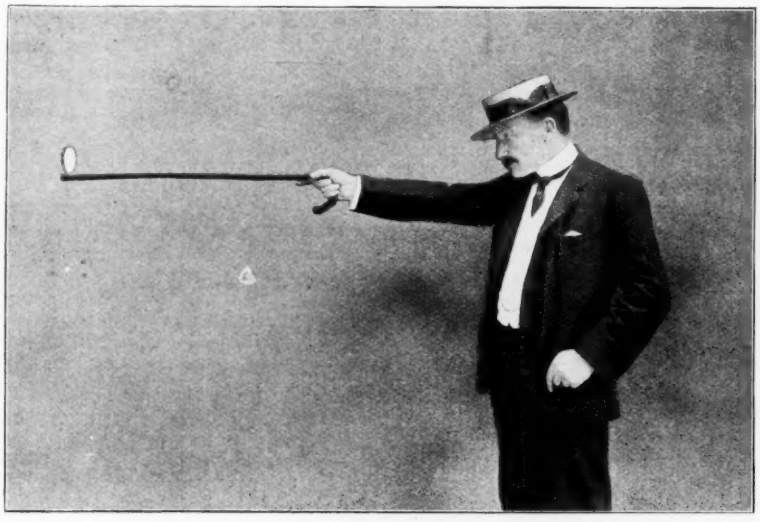
The "Unilens," A Simple Telescope.

IT is curious how, occasionally, some very simple application of known principles is brought forward as a practical appliance, which, for some reason, has never before been tried, or, rather, widely applied, to the purpose. This is the case with the "Unilens," lately patented by Major Baden-Powell. It consists merely of a convex lens, 2½ inches diameter, having a focal length of about 6 feet. This, mounted temporarily at the end of a stick, enables an enlarged view of distant objects to be obtained, the maximum magnification being about 4 diameters. Considering the extreme simplicity and low cost of the appliance, it should form a most handy glass for all ordinary purposes, comparing favourably as regards power with the cheaper opera and field glasses. As now designed, the glass is mounted on a metal base from which projects a small screw, and it may thus be readily affixed to any walking-stick, &c., while, being so small and flat, it can be carried in the waistcoat pocket.

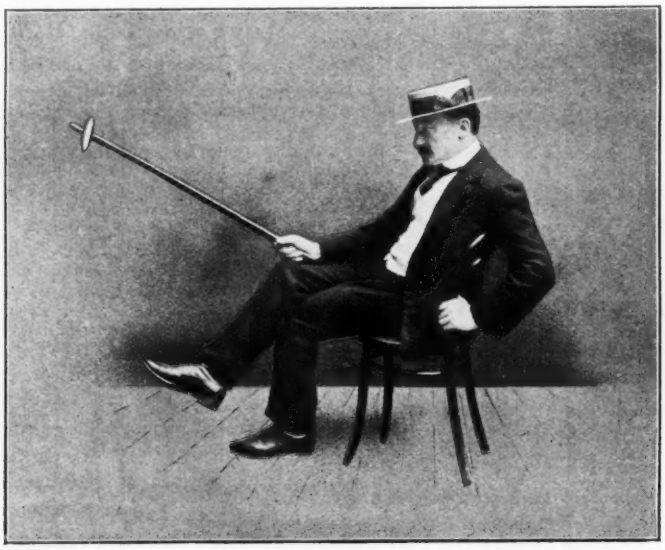
Though there may be no special novelty in this appliance as an optical instrument, yet as a practical means of observation it should prove of great value to almost all observers of Nature. As an astronomical instrument it can, of course, hardly claim a high place, yet so simple and portable an apparatus has its uses. We know how useful even a low-power opera-glass can be in looking on the heavens, and many features are thus clearly shown which are not perceptible to the naked eye. For instance, on looking at the Pleiades through the "Unilens" eight stars can be discerned, although it is seldom that more than six are visible to the unaided vision. The naturalist will certainly find this portable glass of great assistance in watching birds and beasts even at a few yards off, at which distance they are greatly magnified. The botanist, too, may find it of use in examining plants out of reach.



"Unilens" at Full Focus.

This glass has the great advantage of always being in focus. The further it is held from the eye the greater is the magnification. But if it be merely held in the hand at arm's length it is a great aid to natural sight, and is most useful in the theatre or even picture gallery or cathedral. When on the end of a stick, and the stick held at arm's length, that is to say, when the glass is approaching six feet from the eye, objects are seen at the greatest magnification, although they then begin to get slightly blurred.

It need hardly be said that such a glass is not suitable to all eye-sights. Those slightly affected by myopia, or short-sight, do not see well through the single lens. But if these persons use a concave eye-glass as well, not only will they see clearly through the "Unilens," but will improve their sight under ordinary circumstances by the habitual use of the eye-glass. This little appliance is being placed on the market by Messrs. Newton, of Fleet Street.



An Easy Position.

Nature-Study : A Field-Lesson at Werribee Gorge, Bacchus Marsh. (Melbourne : Government Press, 1906).—This well illustrated account of a visit of pupils to the locality mentioned is published as a supplement to the Melbourne *Education and Teachers' Aid*, and shows that the Victorian Government is thoroughly awake to the necessity of going to the original source, if education in natural science is to be of any value. The members of the party were fortunate in having presented to them some excellent specimens of ancient glaciation.

Pendulums Used in Gravitation Research.*

By W. H. Sharp.

The laws of falling or moving bodies were investigated in ages long before Galileo's time (about 1600), and probably with much greater success than is at present commonly supposed. His experiments with bodies falling from the top of the Tower of Pisa were connected with the opening of a new chapter in gravitation research.

Newton, in 1710, made similar experiments in London with bodies falling freely directly downwards to the earth from a great height, and based his celebrated theory of gravitation upon the results attained thereby, and by means of his own famous experiments with vertical pendulums, eleven feet long, suspended from the ceiling of a room.

Two centuries ago the pendulum had become recognised as specially suitable for gravitation research, because it was possible by its means to substitute the gliding motion of a pendulum bob in a smooth curved path or long arc of a circle, for its fall down a short straight path representing the versed sine of that arc, or in other words the vertical depth from top to bottom of that smooth curved path.

Pendulums—and I must be understood to refer particularly to such as are used for astronomical purposes—may be regarded as belonging to one or other of three classes, according as the plane in which they are designed to oscillate is:—(A) Vertical, (B) Horizontal, or (C) Inclined, with reference to the horizon at the place where they are used.

When the pendulum is constructed by hanging a weight at the lower end of a cord, wire, fibre, or other material from one point above, so that the weight may oscillate to and fro, its suspension is said to be unifilar. Newton's was of this kind (see Fig. 1). But, if by hanging a weight by two equal cords, wires, or other materials, from two points above, its suspension is said to be bifilar (see Fig. 3). The unifilar vertical pendulum is like an ordinary plumb-line, and one great objection to it is, that being free to move not only to and fro, but also sideways, it does not continue oscillating in one direction—in one plane—to and fro, but tends to change its direction all the time it continues swinging.

The bifilar suspension imposes a limit upon that tendency to change, and tends to leave the pendulum free to oscillate to and fro in one plane only.

Gauss and Weber used a bifilar suspension, and also the well-known mirror reflecting a ray of light, about 1836, in their pendulum experiments.

(A) *Vertical pendulums*, or plumb-lines have been used in four different ways in gravitation research.

(1) To compare forces acting upon them, by counting the number of oscillations produced in equal times under similar conditions by different forces (Fig. 1).

(2) To compare forces acting laterally upon them, when hung as plumb-lines at rest, for instance near the side of a mountain, by measuring the distances through which they were drawn out of the vertical. Bouguer (1738) and Maskeleyn (1772) used that method, with long plumb-lines near mountain sides, and Gruithuisen (1817) used a ten-foot thread pendulum—his "elkysmometer"—to indicate variations of lunar attraction (Fig. 1).

(3) To demonstrate the rotation of the earth by measuring the rate of angular deviation of the plane of oscillation of a unifilar pendulum. This was done by Foucault in 1851, who proved that the rate of deviation depends upon the latitude of the place in which the experiment is made (see Fig. 2).

(4) To measure, if possible, the "Lunar variation of gravity" by using a vertical bifilar suspended pendulum, as suggested by Lord Kelvin in 1878, with a Gauss mirror attachment, and as used by or for the British Association Committee in the abortive experiments reported for them by G. H. Darwin, in 1881. (*Vide* British Association Reports, 1881-2.)

Among other notable experiments on gravitation by means of vertical pendulums are those of Du Buat (1786), Carlini (at Mont Cenis), Bessel (1826), Horsford's* with a 220 feet pendulum in a tower, and Airy's in a coal mine 1260 feet deep.

In every instance where a vertical pendulum has been used for gravitation research, a weight has had to be lifted against the vertical downward force of the earth's gravitation, and in order to avoid the necessity of so doing, the vertical pendulum was abandoned about the end of the eighteenth century by leading men in the scientific world, who adopted the horizontal pendulum as a more promising instrument of research.

(B) *Horizontal pendulums*—most properly so termed—consist of a rod having a ball at each end, and supported horizontally, after the manner of an ordinary compass needle, upon a point at the middle of the rod. The earth's downward pull upon the ball at one end is exactly balanced by its downward pull upon the ball at the other end of the rod, and there is therefore no need in practice to consider the vertical downward force of gravity so far as such a pendulum is concerned. There is also no reason why such a pendulum under ordinary conditions should tend to rest in any one particular horizontal direction rather than in any other. In fact it is not known as having any definite directive tendency.

It is an immense advantage to be able to work upon delicate gravitation research without interference by the earth's downward attraction, but immediately one begins to avail of that advantage, the need of a definite directive tendency is obvious. A magnetic needle has a tendency to set in one definite direction, and we may use various means to cause it to depart therefrom, and measure the angles or distances through which it is moved thereby, for the purpose of comparing the forces involved. So also the plumb-line or vertical pendulum had a definite directive tendency to adopt the nearest position to the earth's centre, and in a straight line directed thereto.

Coulomb overcame this difficulty by suspending the horizontal rod—with the balls at its ends as aforesaid—by attaching a wire at the middle (or centre of gravity) of the rod and fastening the other end of the wire to a point above. This was instead of using a pointed support, as in the mariner's compass, and with such a wire suspension the rod always had a definite tendency to take up and maintain a certain direction which was determined by the molecular arrangement of the particles of the wire suspension, etc. (see Fig. 4).

He called his horizontal pendulum, so suspended, a torsion balance, and the horizontal pendulums after-

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* *Vide* Proc. Am Assoc. for Advancement of Science, 1852.

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wards used by Cavendish (1798), by Reich (1836), and by Baily (1842) in their famous gravitation experiments were nothing more nor less than torsion balances, even though bifilar silk fibre suspensions were in some cases used instead of a single wire suspension to give definite directive tendency to the pendulum rod, by limiting its freedom (see Fig. 5).

The advantage of definite directive tendency gained by suspension, whether unifilar or bifilar, and whether by cord, wire, fibre or other material, was only gained at the cost of restoring in some degree the disadvantage of having to lift to a very slight extent against earth's vertical downward attraction the weight of the pendulum rod with its two balls. For torsion implies twisting, and consequent shortening or lengthening of the suspension, and raising or lowering of the rod, etc. And granting that in alternate excursions of oscillation, about a mean direction line of rest, the raising and lowering involved might be equal and opposite in amount, and neutralise each other, yet the fact would remain that the path of each ball would tend to have a slightly spiral form, and not be strictly horizontal.

With those horizontal pendulums pairs of large attracting masses were used, and these were so placed near the pendulum balls that their attractive forces were exerted at the same time, so as to produce a combined rotational effect in the same direction in the approximately horizontal plane. That rotational effect, or lateral pull, with reference to the definite direction line, or mean line of rest, was calculated from the number of oscillations, the weights and distances of the attracting masses involved, and the times, by using Coulomb's formula, etc.

A very full account of the latest of those experiments, and reference to others made previously, will be found in Vol. 14 of the "Memoirs of the Royal Astronomical Society, 1843." In all cases of such experiments on gravitation, with horizontal pendulums, "anomalies" of attraction were noticed, resulting in a "march" of scale readings, or "reversals" of direction, etc., for which the observers were unable to account. Such anomalies were discussed by Poisson (1834), Plana, John Herschel, Herne, and others mathematically and otherwise. Grant's "History of Physical Astronomy" may be consulted for further reference thereon.

(C) *Inclined pendulums.*—These are wrongly called horizontal pendulums usually, and apparently for no better reason than that the rod used is sometimes approximately horizontal, and is intended to be used in the investigation of force exerted in a horizontal plane. But they do not oscillate in a horizontal plane, they are not as a rule even intended or designed to do so. Implicitly or expressly, others are designed so that they are not horizontal, and can only be properly used in inclined planes.

The absurdity of classing these pendulums with those of the class which contains Coulomb's and Cavendish's pendulums will best be appreciated by observing the essential distinction which exists between them. The Coulomb and Cavendish class, in addition to the characteristics already noticed, involves two weights on one rod, and the earth's downward attraction upon one of those weights is balanced by the similar attraction upon the other, as at the opposite end of a lever having its fulcrum in the middle or where the suspension line is attached, and where the centre of oscillation is supposed to remain constant in position, but in practice cannot and does not do so. Whereas the inclined pendulums have a weight only on one end of a rod, and in consequence of having no counterbalancing weight at the other end to neutralise the earth's attraction upon it, various different devices have been used to effect that neutralisation otherwise than by using a second weight, and subject to the retention of a very minute unneutralised fraction of its own weight merely for the sake of imparting definite directive tendency by inclining the pendulum specially for that purpose. Moreover, while those in the former class never have a constant centre of oscillation, those in the inclined class may have, and in some instances practically have.

Hengler's Pendulum (1832), appears to be the first inclined astronomical pendulum known in modern times. His account of same I found this year (1906) in *Dingler's Polytechnisches Journal*, 1832, printed in the old German characters. I know of no translation ever having been published in the English language, and have had to make a translation specially for my own satisfaction.

His rod was suspended by a short cord or wire from a point in the ceiling and so that the length of the rod was divided into two very unequal portions, as a lever having unequal arms. At the outer end of the longer arm he hung a small weight, and at the outer end of the short arm he tied one end of a long cord (or wire), which extended downwards to and had its lower end fastened to the floor at a point almost vertically below the point aforesaid in the ceiling. He arranged the rod almost horizontally by adjusting the length of the long cord going to the floor and the function of that long cord was primarily to supply by its tension a counterbalancing force against the weight on the other arm. So he avoided the use of a second weight, and it is obvious that the small weight at the outer end of the long arm might oscillate in the arc of a nearly horizontal circle, about the centre of oscillation, which was at a point intermediate between the two points of attachment of the cords aforesaid, to the rod (see Fig. 6).

Of course, "torsion" effect was a factor, as well as gravity, in determining the direction that the rod would tend to assume at rest, but he clearly saw the importance of setting his pendulum to oscillate in an inclined plane, for he discusses its angle of inclination, etc., and designed his pendulum to oscillate therein. He set the rod so as to rest in the meridian at noon on a day of new moon, then closed the room, and observed the oscillations of the weight by means of a powerful microscope from outside the room.

He devised also a similar pendulum, having a separate stand, so obviating, if required, the necessity of direct attachment to the building in which experiments were to be made.

With one of his pendulums he claims to have observed lunar attraction effects, and with another, earth rotation effects. His statements as to the diurnal variation which he says he observed are very interesting. More will be heard about such matters presently. He was a pupil of Gruithuisen (*vide* Safarik, Vol. 46, *Phil. Mag.*, 1873). Both master and pupil have been gratuitously villified since their decease by very plausible people, who had ends of their own to serve, by belittling others that they by contrast might appear great.

Hengler was a genius, and by dispensing with the necessity of using a second or balancing weight, as used in the class of so-called "horizontal" pendulums,

he opened a new chapter in gravitation research, which is more than his traducers were capable of doing apparently.

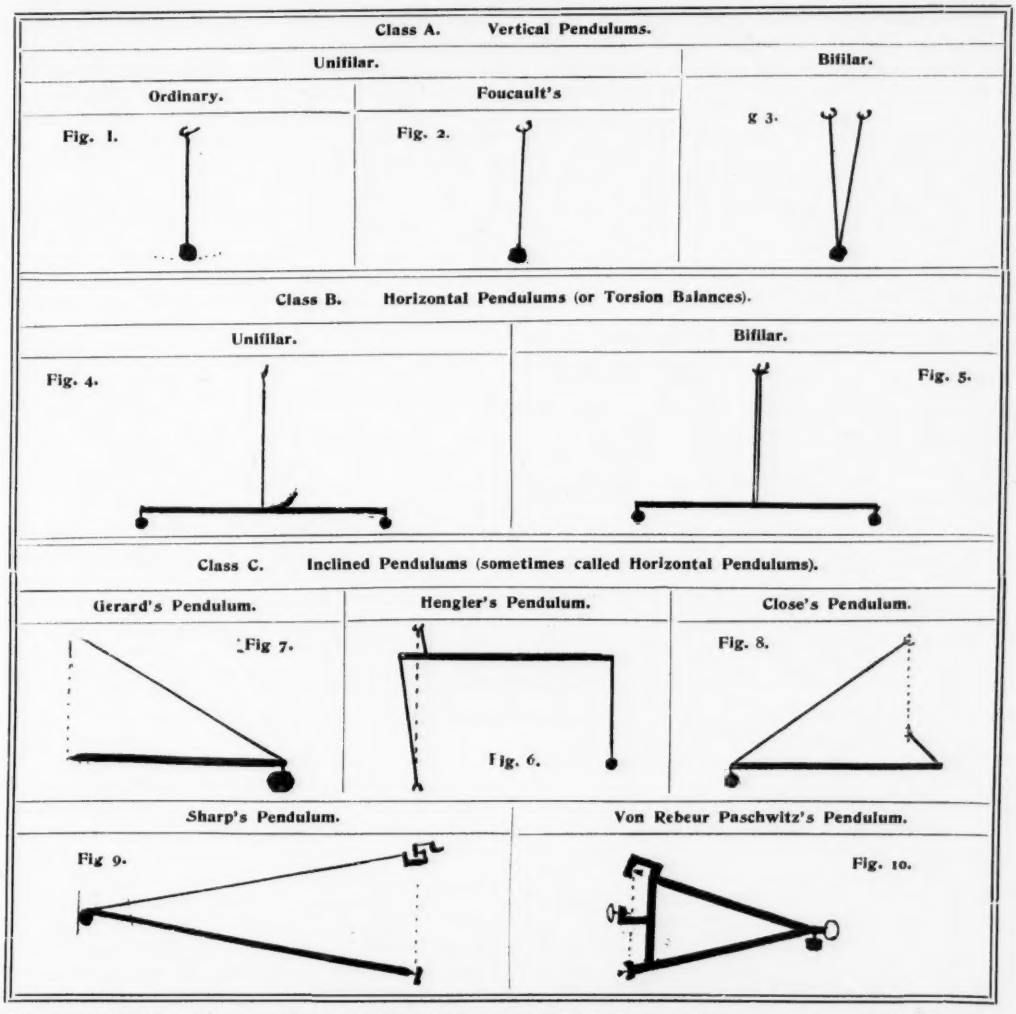
Gerard's Pendulum (1851).—Described as "horizontal," but which had only one weight—about one hundredweight block of granite—at the end of its rod. The rod was a strong composite deal beam, provided with a point at one end, and had the weight hung at the outer end (see Fig. 7). A copper wire was fastened to the weighted end of the "rod," and the other end of that wire was hooked into a ring fastened into a wall. The pointed end of the "rod" pressed against that wall at a point nearly vertically below the ring. The rod was nearly horizontal, and took 15 seconds to make one oscillation. The experiments were made in a room, and diurnal changes of position were noticed by means of an index moving over the surface of a table. The maximum change appears to have taken place on a day "of bright sunshine," and was "as much as one-fifth of an inch." (*Vide Edin. New. Phil. Jour.*, 1853.)

That pendulum represents an important step in advance, as regards obviating partially the uncertain position of the real or virtual oscillation centre of previous horizontal pendulums and of those classed as such.

Perrott's Pendulum (1862).—This was practically upon Hengler's principle, but had, like one of his pendulums, a separate stand. The chief difference was as regards the materials used for suspending the rod and counterbalancing the weight carried by the rod. Other differences were merely of detail or accessories. (*Vide Comptes Rendus*, Vol. 54, page 728, for results obtained by its use.)

Close's Pendulum.—The date of this is indicated in "Barrett and Brown's Practical Physics," published in 1892, as being shortly before Zollner's, which latter was invented about 1872. It consisted of a rod, having

Outlines showing principles of suspension or support of various kinds of Astronomical Pendulums.



N.B.—The dotted lines in Figs. 6 to 10 inclusive show the axis of oscillation, and though they appear to be vertical, they must be understood to have the upper end of each axis leaning forward out of the vertical and towards the weight, usually.

a weight at one end, and the rod was suspended from a separate stand, by two unequal silk threads attached to the ends of the rod respectively. The longer thread —from the weighted end—was extended backwards and upwards to a point in the front surface of a vertical support, and was there fastened. The shorter thread was extended from the other end of the rod, forwards and upwards, to a point in the rear surface of the same vertical support, and was there fastened so that the weighted rod hung freely, approximately horizontal, as in an unequal bifilar suspension (see Fig. 8).

Close found his pendulum so sensitive that it was moved through an easily measurable angle if finely adjusted, when the whole ground floor of the house, in the basement of which his pendulum stood, was tilted "over to leeward" by a moderate gale. I know of no other observations made with it or results obtained thereby.

Zollner's Pendulum (1872). This, like Perrott's, was practically upon Hengler's principle. Zollner himself credits Perrott with having invented the "horizontal pendulum," but as he also quotes from Hengler's paper and discredits the results therein reported, it is amazing that he did not credit Hengler with the invention of it, unless he meant to confine the credit to the modifications introduced by Perrott and added to by himself. If so, Hengler's credit is the greater.

Zollner used a separate stand, and made modifications in detail, besides using such long previously well-known accessories as the Gauss mirror, etc. *Vide* "Poggendorff's Annalen," 1873, wherein it may be seen that Zollner's object was to investigate as to the "origin of the earth's magnetism," etc., also the results obtained by the use of his pendulum may thereby be traced.

On the 22nd February, 1880, a great earthquake in Japan, led to a meeting being convened there, and at which the Seismological Society of Japan was established, for the special purpose of investigating earthquakes. From that time, seismology, as a science apparently dates. The importance of seismometry as affecting gravitation research, and *vice versâ*, has not yet been fully realised; nor has the action of bodies outside the earth as affecting both been much more than guessed at, and to a very slight extent definitely experimented upon.

No doubt seismological investigations had previously been made in Italy and elsewhere, for in the *Bulletino*, 1876, page 5, Rossi describes instruments previously used for that purpose; and the experiments of M. d'Abbadie, with a dish of mercury, of Plantamour, with a level, and of Siemens, with the "Attractionmeter," as reported in *Phil. Trans.*, 1876, are distinctly related thereto. But after 1880, a particular distinction specially affecting so called "horizontal" pendulums requires to be noticed.

Previously the characteristic of astronomical pendulums had usually been that the earth's surface in the locality where they were respectively used, together with the building, or rigid support to which they were suspended, was considered as at rest, in relation to the oscillating pendulum weight. But the usual characteristic of seismological pendulums is directly opposite thereto, for the pendulum weight, by its inertia, is supposed to remain usually in relative rest, and to serve as a fulcrum for the pendulum rod which is considered to have its axis of oscillation moving with changes of the earth's surface. In fact, the rod is simply regarded as having the function of a lever in these instruments, and the motion of the stand at one end is either recorded by a writing point or ray of light at the other, or the angular deviation of a ray of light or scale image, by means of the well-known Gauss mirror method, is, if necessary, photographically recorded as magnifying that of the stand, when the mirror is attached to the rod or its weight. Oscillations of short-period earthquake waves, apparently, are chiefly sought to be recorded by means of seismographs in general use.

Ewing's Seismograph (about 1881), described in *Ency. Brit.*, N. S., Vol. 27, page 605, appears to have a seismographic lever, which is therein called a "horizontal pendulum," consisting of a frame of metal working gatewise upon two points, and carrying a large ball of metal, which has a long writing pointer attached. I am not aware of any publication prior to 1881 of such a "two-point" suspension, though I had used such long before without publication, and so far the credit of prior publication of a "two-point" suspension is his to the best of my information.

The "two-point" lateral suspension is a step in advance upon the "ring and one point" lateral suspension used by Gerard, but I have been unable to find an instance of any astronomical or cosmic observations having been made by the use of this instrument, which might benefit gravitation research, nor even of any attempt to apply it for the purpose of such discoveries. That, however, may be due to my having been ignorant even of its existence until I heard of it in July, 1906, as containing a "two-point" suspension. The "suspension" and "frame" are in principle like Fig. 10.

Sharp's Pendulum, invented by the writer hereof about 1875, and used in gravitation research until date of its first publication, in February, 1885 (*vide Jour. L'pool Astron. Soc.*, March, 1885), was essentially an astronomical and inclined pendulum, expressly not horizontal. It consisted of a tube or trussed rod (or boom), having a ball at its outer end, and a needle point at the other, but I now prefer to use a rod having a star or + shaped section when I cannot get suitable tube. A cord or wire of brass, aluminium, or copper, was fastened at the outer end of the rod and carried backwards as a stay to a reversed needle point, forming part of a steel bolt driven into the solid angle of the room walls just below the ceiling. That wire ended in a stirrup, the interior surface of which was hardened, and had a minute indentation made therein with a fine "centre punch." That stirrup was hooked upon the reversed needle point so that the point entered the indentation, and was thereby prevented from sliding out of place. The point of the rod below in the solid angle of the walls, near the floor, rested in a similar indentation in a hardened surface, which was mounted on a compound lathe slide rest, giving definite and convenient control of its position, so that the lower needle point could be brought as was requisite almost vertically below, but a little in rear of the line containing the upper point (see Fig. 9).

The rod formed the lower, and the stay formed the upper, of two sides of an isosceles triangle, of which the third side was wanting, and the pendulum oscillated like a > shaped gate, upon the two needle points as hinges. The needles, of course, were in line with the pressures they had to oppose. With adequate time and patience no difficulty whatever was experienced in obtaining the normal variation curve of daily and monthly lunisolar changes, by direct readings from a scale of millimetres, taken by means of an ordinary

pocket telescope, after once suitable conditions had been found. In fact, it was quite possible to take sufficient observations of the index oscillations from the sixteenth of an inch divisions of a common foot rule, by using a pair of opera glasses, to enable charts of lunisolar variations to be obtained.

Of course, the earth and the pendulum ball both move relatively to extra terrestrial bodies, and the recording of earthquakes and tremors might more fitly be entered upon when the larger regular changes are first recognised and charted. Else the diurnal oscillations are liable to confuse the earthquake oscillations. However, these latter have not been my objective, and have not obtruded upon my other work.

It was most convenient to me to consider the pendulum curves as affording comparative and undeniable evidence in themselves without troubling as to whether the ball was at rest and the building oscillating, or the building at rest, and the ball oscillating, or as to whether both were, and to what extent, oscillating. In accordance with the same convention as that by which we regard the Greenwich Observatory at rest, when observations are made through its large telescopes, so far also I was entitled to consider the buildings at rest in which I made my observations. If they moved, Greenwich Observatory (worse situated)* must indeed, have executed serious oscillations involving all its telescopic observations in error.

The advantages of using this kind of pendulum I found to be: (1) It can be made, fixed, and used in any ordinary house, by a person of ordinary intelligence, from common materials, for a few shillings. (2) It gives direct readings, and therefore its evidence is superior to such as might be got by using reflected rays from Gauss mirrors, from photographic recording instruments, or from counting oscillations, and calculating on the assumed accuracy of certain formulæ, and so on. (3) There are no restrictions whatever as to its use, such as patent rights or aught of that kind.

I am not aware of any better means of investigating gravitation, and I say this after having been engaged therein more or less continuously for forty years, solely on my own account, independently, and after recent enquiries as to what others have done in pendulum construction and use.

I use three pendulums simultaneously, one in the meridian plane, one in a plane at right angles thereto, and one with means of observing vertical component.

Von Rebeur Paschwitz's Pendulum (1892).—This so-called horizontal pendulum also has a "two point" lateral suspension. The rod is replaced by a triangular frame after the style of Ewing's seismograph aforesaid, which it much resembles, though it is alleged to have been based upon Zollner's pendulum, which it does not resemble save perhaps in regard to the use of a Gauss mirror, and angular deviation therewith of a ray of light. In fact, it is a seismograph, and has been very widely adopted for seismographic purposes, although Paschwitz himself made observations with it upon the variations of gravity, etc. (see Fig. 10).

It must be understood that in using pendulums of any of the above descriptions involving points working upon bearing surfaces, the rod may have the point, and the wall or support may have the bearing surface, but if more convenient, the rod may have the bearing surface, and the wall or support may have the point. Also it is obvious that any pendulum may have a Gauss mirror attached, in order to use the angular deviation of a ray of light or reflected scale image for magnifying its motion, and that recording apparatus of any kind—automatic, photographic, or otherwise—may be used as convenient. Stands, set screws, and levelling or adjusting devices are useful, but by no means necessary. I prefer to use aluminium, or brass tube for the "rod" or "boom."

There is no doubt that each of the pendulums herein named were independently invented to suit the special enquiries, available materials, and environment of their inventors, as the literature of pendulums is comparatively limited, and what there is of it is very difficult to find, and almost inaccessible, owing to the vast accumulation of literary matter in which it is buried in different places over a very great area.

At a future date, with the editor's permission, I may give some charts of lunisolar observations, taken with my pendulum, and give the results of my experience as regards the best method of erecting, adjusting, and using pendulums for making same.

* My latest observations were made here in 0° 3′ E. Lon., 51° 32′ 40″ N. Lat., 19 feet above Trinity high water mark and three miles from nearest part of tidal river Thames.

CORRESPONDENCE.

Electrical Nitrates and Fertilisers.

To the Editors of "Knowledge & Scientific News."

Sirs,—The article under the above heading in your last issue opens with the following sentence:—

"At present the world's wheat supply depends chiefly on the continued productiveness of a strip of territory in Chili."

With all due deference to the writer of the article, I would point out that this statement is very far from being correct. Nitrate of soda is, no doubt, being worked in increasing quantities in Northern Chili, and there is a large demand for it as an artificial manure. Probably less of this fertiliser is, however, applied to wheat than to any other important crop. Nitrate of soda in British farming is applied principally to turnips, mangels, cabbages, and grass, much less commonly to any corn crop.

Wheat is in no sense dependent for its profitable cultivation upon nitrate of soda.

The value of calcium cyananide as a nitrogenous manure as compared with sulphate of ammonia has been tested at Rothamsted Experimental Station, and an account of the experiments will be found in the "Journal of the Board of Agriculture," for July last.

I am, yours etc.,
J. H. M. H.

Electrical Bleaching.

There is good reason for believing that the excessive whitening of flour deprives it of its nutritive qualities. Nevertheless, devices for bleaching it continue, and an electrical method is cheap and is said to be successful. A current of air is passed through a closed chamber, in which is a long high-voltage electric arc. The air thus electrically burnt is then passed through the flour as an agitator, and becomes whitened in the process. Presumably the discharge of the electric arc produces compounds of nitrogen and oxygen in the air which act as bleaching agents. This method is essentially different from the other electric processes of bleaching flour by ozonising the air passed through it. In that process the air passes through a chamber in which there is a silent electric discharge. A combination of the two processes is suggested, the ozonised air being subsequently burnt by the arc discharge. A machine has been patented, and is actually in use.

XUM

Photography.

Pure and Applied.

By CHAPMAN JONES, F.I.C., F.C.S., &c.

Photographic Exhibitions.—The annual exhibition of the Royal Photographic Society at the New Gallery, 121, Regent Street, is now open, and will close on the 27th of October. All sections are of interest and are well represented, but we naturally turn to the technical section. The preponderance of photographs of birds continues, if it does not increase. Nature, as we know it, does not consist chiefly of birds, but one or two indefatigable workers appear to have set the fashion in this direction, and a considerable number of photographers, the most of them less skilful than their leaders, have followed in the groove. The time is past for showing an isolated photograph of a bird, unless it is a very rare specimen or has some very special reason for its exhibition. Mr. W. Farren's series of twenty-four photographs, showing the life history of the stone-curlew, and Miss E. L. Turner's grebe series, are highly commendable. A few years ago, similar series, illustrating the growth of certain plants were shown, but this year Mr. A. W. Dennis contributes a series of a different kind. He illustrates wych elms, and fine examples of them, in their different conditions as to seasons, and also, on suitable scales, the various details of their parts, such as the winter buds, the leaf, the blossom, the fruit, etc. A most interesting exhibit to those whose knowledge of the aberrations of lenses is not very precise, is a series of models made by Mr. Welbourne Piper, that clearly illustrate the paths of the rays under various conditions by means of threads of different colours. There are nearly three dozen models on the six frames. For this new departure in the illustration of the effects of lenses that are of prime importance in photography, the judges have awarded a medal. We look in vain for any evidence of progress in the department of colour-photography. The best of the examples are not better than what has been seen before. An invitation collection includes recent work from the Greenwich Observatory and the Solar Physics Observatory, Dr. W. J. S. Lockyer's series of cloud photographs, a large series of photographs of electrical discharges by Mr. K. J. Tarrant, further work by Mr. Edgar Senior on the Lippmann method of colour photography, and other exhibits of much interest. In the North Room there are several examples of "ozobrome" prints, with the bromide prints from which they have been produced.

There are two other exhibitions now open in London that are of great interest to those who photograph, though not from a scientific point of view. The "Photographic Salon," at the Gallery of the Royal Society of Painters in Water Colours, 5a, Pall Mall East, is devoted entirely to pictorial work, and closes on the 27th October. A collection of portraits by the late Mrs. Julia Cameron, and by her son, Mr. H. H. Hay Cameron, will be on view till the 6th of October, at 24, Wellington Street, Strand. These pictures of Mrs. Cameron's include some of the finest photographic portraits (and one might perhaps almost omit the word "photographic") ever produced, and of the finest subjects, for there are portraits of Carlyle, Tennyson, Browning, Longfellow, Darwin, Sir John Herschell, Joachim, Watts, and Miss Ellen Terry at the age of seventeen.

The Purchase of Photographs.—The greater number of the photographs in the exhibitions above referred to can be purchased, as is usual in picture exhibitions. During the last ten years, or rather more, it has become fashionable to omit all reference to the nature of pictorial photographs, that is, what the image consists of, or how it has been produced, for fear, I suppose, lest they should be bought as specimens of processes instead of because of their pictorial merit, or for fear the artist should feel handicapped in their production, not always knowing himself what his methods lead to. There are many photographers who take great care that their pictures contain nothing but what may fairly be called permanent, but others are not so scrupulous. A fine effect may be obtainable in fugitive material, and through ignorance or indifference they avail themselves of a process or a detail in the process that they ought to absolutely shun in any picture that is offered for sale. As the possible variations in photographic methods are more numerous than in any other current method of pictorial expression, this reticence is a distinct disadvantage to the would-be purchaser and doubtless also to the photographer.

Colour Photography.—Professor Lippmann has recently described in the *Comptes Rendus*, another method of colour photography. A plate that is opaque, except for fine parallel lines, about 125 to the inch, is fixed at one end of a light-tight box, a photographic plate is at the other end, and a lens between is so arranged that it forms a sharp image of the grating on the plate. A small angled prism is fixed near the lens so that the light that passes through each line (as through the slit of a spectroscope), is dispersed into a spectrum, but so short a one that it only just covers the otherwise blank space between the image of one light line and the next. Instead, therefore, of a series of separated fine lines on the plates, the surface is covered with lines of colour, very much as if a Joly compound colour screen were in front of it, but there is a spectrum instead of each group of three coloured lines. An image of the coloured object that is to be photographed is projected by ordinary optical means on to the grating, the exposure is made, and the plate developed. By putting (I suppose) a positive, made from the negative in exactly the place occupied by the negative during the exposure and illuminating it with white light, a coloured image, similar to the one photographed, will be produced in the plane originally occupied by the grating. It is obvious that the ultra-violet must be excluded, the plates must be sensitive to the whole of the visible spectrum, and other precautions must be taken that need not be enumerated. It is a pretty and interesting method that must need very nice manipulation to ensure success.

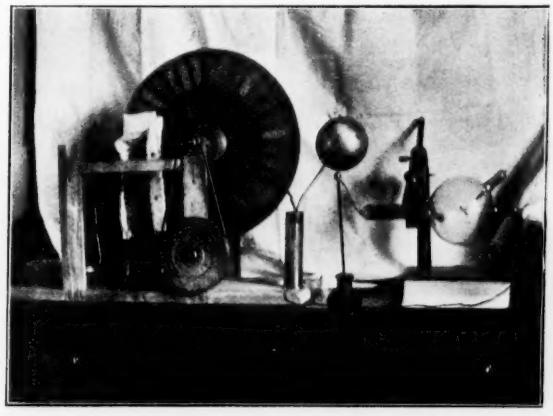
Colour-Sensitised Plates.—Messrs. Wratten and Wainwright send us a sample of their "Allochrome" plates, which are sensitised for green and yellow, but not for red, and are thus comparable with the colour-sensitised plates that are best known and made by many makers. The sample is of excellent quality and backed with a black backing that does not detach itself, but is easily removed when done with. This, with the plates referred to before, makes a very complete series, and a booklet that the firm have just issued describes the many kinds of plates that they make, including five varieties of plates specially sensitised for colour, and gives advice as to their use. Colour screens or filters of various kinds and of three densities, specially suitable for use with the plates, and others for three-colour work, are issued by the firm.

XUM

The Celluloid Electric Machine.

By Charles E. Benham.

The value of celluloid as an electric has hardly been fully realised, and the use of it has, perhaps, been prevented from considerations of its inflammability. There is no danger whatever on that score in employing it in the manner about to be described. The electric properties of celluloid are somewhat mysterious. It is not a particularly good non-conductor, yet at the least friction with silk or other suitable rubbers it is highly electrified. Its electric potency increases, and often a sample that is quite new will hardly give any electricity, and yet after a few weeks it becomes powerfully excited by friction, and Dr. J. N. Goldsmith, of the Xylonite Works at Brantham, states that this increase of efficiency goes on to a maximum, and then, after a course of many years, gradually declines. It is not nearly so sensitive to atmospheric conditions as glass or



The Celluloid Electric Machine.

[The illustration shows a machine with two 16-inch glass plates, mounted about half an inch apart on one spindle. The outer surfaces of the plates are varnished with celluloid, and each is lightly pressed by a silk cushion seen on the left. The inner surfaces of the discs have tinfoil sectors which are earthed by a brush placed between the plates where they pass the silk rubbers. The prime conductor is connected with a small Leyden jar, a pointed wire projecting from it between the discs to collect the charge from the sectors. The attachment for the X-ray tube is also shown. One terminal of the tube is connected with a small insulated brass ball, placed about half an inch from the prime conductor. A wire is led from the other terminal to the outer foil of the Leyden jar.]

most other electrics, and the machine about to be described will start readily under ordinary conditions without any preliminary warming. The spark is not, of course, so strong in wet weather, as is also the case with the influence machine, but the falling off is probably due to the defective insulation of the parts of the machine under such circumstances rather than to any difference in the action of the celluloid itself.

In the April number of "Knowledge" a simple gas lighter made of celluloid was briefly described, and it may be mentioned that such a device may be made equally well, or, perhaps, with advantage, by employing a glass tube coated with celluloid instead of a tube composed of that material. Celluloid is readily soluble in amyl acetate, and the varnish thus formed may be applied to glass, and when dry there will be a very tenacious film of celluloid on the surface which becomes highly electrified under the influence of a silk rubber.

Instead of coating a glass tube in this way, the surface of a glass disc may be varnished with celluloid, and a very efficient plate machine of extremely simple design may thus be constructed.

It should be mentioned here that a curious mistake is made in the construction of the old "plate machine," which, of course, is not often seen nowadays except in class-rooms as illustrative of electric principles. This mistake consists in the use of two rubbers—one on each side of the glass. If one rubber on one side of the glass is used and in place of a rubber on the other side an earthed brush grazes the glass, there will be quite as much electricity produced as with the two rubbers; while much less friction is involved. The brush increases the capacity of the plate where the rubber is applied, and a second rubber, instead of the brush, only does the same thing less effectively. The side away from the rubber and touched by the brush may advantageously be furnished with tinfoil sectors. Each sector passing the brush when it is under the influence of the rubber has its capacity largely increased, and when free from the brush, passes the collectors with correspondingly reduced capacity, and, consequently, yields its charge to them readily. This applies quite as much to the old-fashioned plate machine as to the celluloid machine, and it is strange that the arrangement never seems to have been adopted.

The celluloid machine is made upon the plan just described, the rubber being of silk, and no amalgam being used. Japanese silk is particularly good for the purpose. There is also no special advantage in making the plate pass the rubber twice in the course of a revolution, as in the Ramsden plate machine. Winter's plan of single collectors for each revolution will be found the best. It is equally a question whether any advantage is gained by making the collectors embrace both sides of the glass. Experiments do not at all indicate that there is any increase in the output thereby.

All these considerations make it clear that for an efficient machine the construction will be of the simplest kind with the accompanying advantage of a minimum of leakage, which is sure to be introduced together with any unnecessary complications of the apparatus and an increase of the number of parts. The revolving disc, turned with winch and pulley, passes a silk rubber pressing against the left side of the disc, and at the same spot the sectors on the opposite surface are successively earthed by a brush. Passing round, the sectors deliver their charge to the collectors, a row of points connected with a prime conductor and facing the sectors on the right hand side of the disc. Care must be taken that the rubber presses only lightly against the glass, so as to avoid any risk of breakage. The celluloid varnish is applied to the back of the glass only, and should not be brought up to the centre of the disc, for, as already stated, it is not a very good insulator. All the rest of the disc, except, of course, the surface of the tinfoil sectors, should be coated with shellac varnish.

A more powerful machine may be made by using two such discs with the tinfoil sectors facing each other. The two discs should be mounted on the spindle so that they are about half an inch apart. A rubber is placed against each disc on the outside surfaces at the left, a double brush on a wire support being fixed between the two discs so as to touch the sectors of each simultaneously. The collector is simply a pointed

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wire projecting from the prime conductor, so that its point is between the two discs on the right hand side. Attaching a small Leyden jar to the prime conductor a very strong spark, well suited for X-ray work, is obtainable. The spindle may be made long enough to carry further pairs of plates in the same way, with increased output. To regulate the pressure of the rubbers, they should be on hinged supports so as to be quite free to yield to outward pressure, while a curved springy piece of thin brass wire is made to clip lightly the two supports and thus hold the rubbers pressing gently against the glass.

ASTRONOMICAL.

By CHARLES P. BUTLER, A.R.C.Sc. (Lond.), F.R.P.S.

Mills Expedition to the Southern Hemisphere.

AT the close of the two-year period of actual observation in October, 1905, by the D. O. Mills Expedition to Santiago, Chili, Mr. Mills most generously offered to continue the work for five additional years. He has also provided for extensive improvements in, and additions to, the equipment of the Observatory. Two-prism and one-prism spectrographs have been built, in order that radial velocity determinations may be carried to the fainter stars. Professor Wright's experience has made it practically certain that rapid changes in focal length and other sources of disturbance in the stellar images are due to rapid changes of the temperature of the mirror during the first hours of the night. Dr. Curtis has designed a refrigerating apparatus, which has been sent to Cerro San Cristobal for trial. It is hoped that by the use of this the apparatus may be kept at a sufficiently constant temperature.

Accelerated Motion of Jupiter's Great Red Spot.

Mr. W. F. Denning, writing to the *Observatory* for September describes some recent observations he has made on the Great Red Spot on Jupiter during the present year. Towards the close of the last opposition, March to May, 1906, his measures showed that the rate was as nearly as possible conformable with that of System II., based on a rotation period of 9h. 55m. 40.6s. On re-observing the planet before sunrise on August 9, however, he immediately saw that the Red Spot and Hollow were far in advance of their predicted places. This was confirmed by the Rev. T. E. R. Phillips on the morning of August 11, and by another observation obtained by Mr. Denning on August 16, showing that in a period of little more than three months the markings have lost 16°, equivalent to $26^m\ 29^s$, relatively to the zeromeridian of System II. In other words, while the rotation between March 24 and May 4 was 9h. 55m. 40.6s., it had become only 9h. 55m. 33.8s. between May 4 and August 8. The latter period is the same as that exhibited by the Red Spot during 1879.

Mr. Denning notes that the dark material (extending over about 63° in longitude), forming the South tropical disturbance on Jupiter, must have been in central conjunction with the Red Spot in June last, and he thinks that it may have been responsible for the marked increase of velocity shown by the latter. Even then the recent acceleration in the motion of the Red Spot is far greater than has ever been previously observed, and either the Hollow in the South Equatorial belt or the Red Spot appear to have been visible for the past 75 years.

Recent Observations of Phoebe.

In the 118th Circular of the Harvard College Observatory, Professor E. C. Pickering gives the reductions obtained from six photographs of Saturn's satellite, Phœbe, during this year. They were taken during May and June, with the 24-inch Bruce telescope, at Arequipa, the plates being exposed for about two hours each. The following table shows the co-ordinates of the satellite at the times noted :—

Date.			G.M.T H	G.M.T M	Distance.	Position. Angle.
					/	°
1906.	May	18	21	3	25·7	245·0
	,,	19	21	7	25·7	244·7
	June	25	19	0	23 3	247·3
	,,	26	18	55	23·2	247·2
	,,	27	18	59	23·0	247·1
	,,	28	18	53	22·9	246·9

The System of Castor.

Mr. H. D. Curtis gives a complete discussion of the Lick Observatory plates of the spectrum of α Geminorum, Castor, with correlative comparisons with the measurements made at Pulkova, by Belopolsky. Most of the plates were taken with the re-mounted Mills spectrograph, with λ4,500 central, the region of spectrum investigated extending from λ4367.839 to λ4629.521. Both components of the star are of the Sirian type, being catalogued in the Harvard classification as A and VIIIa. The absorption is somewhat more complete in a_1, the fainter component, than in a_2. The plates for measurement were exposed for eighteen minutes to the brighter component, and forty-four minutes to the fainter component.

a_1 Geminorum; fainter component, south preceding; magnitude, 3.7.—The binary character of this component of Castor was discovered by Belopolsky at Pulkova, in 1896. The elements deduced from the Lick plates are :—

Period = 2·928285 days.	
τ = J.D. 2416828·057	± 0·042 days.
e = 0·01	± 0·0066
μ° = 122°·939	
ω = 102°·516	± 5°·120
κ = 31 76	± 0·22
Velocity = − 0·98 km.	± 0·15 km.
a Sin i = 1,279,000 km.	

a_2 Geminorum, brighter component; north following; magnitude, 2.7.—The variation in the radial velocity of this component of Castor was discovered by Curtis in October, 1904. The final elements of the orbit are :—

Period = 9·218826 days.	
τ = J. D. 2416746·385	± 0·021 days.
e = 0·5033	± 0·0112
μ° = 39° 05053	± 0·00046
ω = 265°·353	± 1°·730
κ = 13·557	± 0·218
Velocity = +6 20 km.	± 0·17 km.
a Sin i = 1,485,000 km.	

The author expresses the hope that a combination of the spectrographic and visual results will eventually give a fairly accurate value of the parallax, masses, and other physical constants of this unique quadruple system; at present the elements of the visual orbit are so indeterminate that no conclusion can be reached at present. It is important to note that in Castor we have two systems whose orbital dimensions are probably of the same order of magnitude. The brighter component has, however, the very great eccentricity of 0.50, while the fainter pair revolve in orbits which are practically circles (e=0·01). This extraordinary difference seems, by the generally accepted theories of stellar evolution, to indicate that the brighter component is the older, and that the fainter is, comparatively speaking, a binary of relatively recent origin. The effect of tidal friction on a system so eccentric as that of a_2 must be enormous, as at periastron the stars are only about one third their apastron distance apart. Such an eccentricity has only been found in those spectroscopic binaries which show variability in their light. A special series of observations were accordingly made with the smaller of the two Bruce double-image photometers, attached to the twelve-inch equatorial. No marked variation of regular period could be detected, so that any existing must be very small. No irregularities

have been detected in the velocity curve of the spectrographic orbit.—(*Lick Observatory Bulletin, 98.*)

New Optical Catalogues.

Adam Hilger, Ltd.—In their latest catalogues, Messrs. Hilger present several important novelties for the consideration of the spectroscopic or astrophysical worker. The list "A," in addition to numerous forms of spectroscope of improved design, contains descriptive illustrations of several new departures in spectroscope designing. For much too long a time the spectroscopic apparatus supplied even for critical research has been made of too light design, resulting in difficulties due chiefly to flexure, and also temperature changes induced by the variety of materials employed in construction. The Hilger "Bar" Spectrograph has been designed to eliminate many of these defects, and a critical examination convinces one that it is sure to give satisfaction, especially for photographic work, where rigidity is so specially necessary. The mounting consists of two triangular bars, connected at their intersection with a thoroughly good, long, conical fitting. The bars are accurately scraped to standard gauges, and on them are mounted the massive carriers for the lenses, eyepieces, prisms, etc. A specially designed clamp is provided for locking each piece in any desired position. As made, the instrument can be provided with either prism or grating, being practically a universal spectroscope or spectrograph. For the optical parts, Messrs. Hilger are prepared to supply prisms made of the new "Uviol" glass, prepared by Schott and Co., for ultra-violet work, but as it does not pass light as far as a quartz-calcite train, it is not recommended for standard work.

The well-known "Evershed" spectroscopes for prominence and spectrum work on the sun, and the new form of Hüfner Spectrophotometer also deserve special mention, but particulars of numerous other pieces of physical apparatus are included.

List "B" contains particulars of the Echelon gratings usually supplied, the largest consisting of 40-plane parallel plates. All these are generally supplied with the auxiliary spectroscope, which is necessary for isolating the particular radiation under investigation. The *Constant Deviation* spectroscope, which is a speciality of the firm, is well adapted for this purpose, and several different methods of arranging the apparatus are suggested.

Carl Zeiss.—The catalogue of astronomical telescopes and accessories just issued by Messrs. Zeiss gives minute details of their instruments, all presented with that beautiful finish always associated with the products of the firm. The views of the erecting shop, where instruments are built up and thoroughly tested before sending out, and the well equipped observatory, where all the objectives are used on the actual celestial objects, all emphasise the care which is taken to produce only one quality, and that the best. The list includes refracting and reflecting telescopes, objective prism spectroscopes, prominence spectroscopes, and all the usual small apparatus of an observatory.

BOTANICAL.

By G. MASSEE.

Vitality in Seeds.

A HIGHLY interesting and well authenticated account is given by Landreth, in *Proc. Amer. Phil. Soc.*, No. 182, of an instance of persistent vitality in seeds. Lieutenant Greely, Commander of the Lady Franklin Bay Expedition, which sailed north in 1881, took out seeds of various vegetables noted for their antiscorbutic properties. Some of these were sown at Fort Conger, 81° 44′ north, but the attempt was not successful. This station was abandoned in 1883. In 1899, sixteen years later, the abandoned station at Fort Conger was discovered by Lieutenant Peary, Commander of the North Polar Expedition. Among other things found was a packet of radish seed in an open box in the attic of the Fort.

These seeds had been exposed during sixteen years to a winter temperature of 60° to 70° F. below zero. The seeds were sent home and remained until the spring of 1905, when they were sown and 50 per cent. produced perfectly normal plants. The original seed was harvested certainly not earlier that 1880, and consequently was twenty-three years old when sown. The question is raised as to whether the electrically charged atmosphere, so constant in northern regions, has the effect of prolonging germinative force. It has been observed that the atmospheric electric currents add quite 100 per cent. to the rapidity of plant growth, and to the development of colour and strength of perfume.

Response to Stimuli in Plants.

Dr. Bose has on previous occasions published some interesting and novel ideas relating to the response manifested by plants to electrical stimuli. In a book entitled "Plant Response as a Means of Physiological Investigation," he fully explains the results of his researches on this subject. The phenomena of fatigue, rhythmic response, polar effects of electric currents, transmission of stimuli, etc., can be demonstrated in plants exactly as in animals, thus proving that the underlying law concerning response to stimuli is identical in the two kingdoms. This conception is the leading idea of the author, and is supported by numerous refined and original methods of research, which are fully explained. Many new and highly ingenious instruments have been devised for such purposes as recording simultaneously the response of two plants placed under varying conditions; for recording the death-spasm of protoplasm, etc. Response in whatever manner expressed, resolves itself into two simple and well defined factors, namely, contraction and expansion. The former is the direct result of stimulation, the latter being the indirect result.

Growth is collectively a multiple response to various stimuli. Death is the outcome of a sudden and irreversible molecular change, accompanied by contraction.

Burmese Lacquer Ware and Burmese Varnish.

A very interesting account is given by Sir George Watt, in the *Kew Bulletin*, of the beautiful examples of native workmanship, in which Burmese lacquer or varnish plays an important part. This substance is furnished by a large deciduous tree, *Melanorrhœa usitata* (Wall.), met with in the open forests of Manipur, Burma, and Siam, and bears the following vernacular names: *thit-si* or *thit-tsee* (Burm.), *khéw* (Manipur), *suthan* (Taleing), *kiatrong* (Karen). In British Burma, the lacquer-ware is of two kinds—(1) in which the article is made of basket-work lacquered over; (2) that in which the article is made of wood, such as the large round platter, with a raised edge, in which dinner is served, round and square boxes, bowls, etc.

For basket-work, strips of a bamboo known as *Tinwa-Cephalostachyum pergracile*, are most frequently used. The baskets with their trays and covers, are so accurately plaited that the rest of the work can be done on a lathe. The interstices of the wicker are then filled with clay and painted with varnish, which penetrates and toughens the clay, and binds the fibres of the wicker. It is afterwards ground smooth on a lathe and various coats of varnish applied.

In some instances the entire surface of an article is covered with engraving. The gloss of the varnish is removed and a perfectly smooth surface produced. It is then handed over to the engraver, often a young girl, who, by means of a fine metal point, engraves a certain portion of a pattern, the spacing and assortment being done by the eye without any previous sketch or copy. The article is then rubbed over with some dry metallic pigment which loads the engraved portions with colour, the excess is rubbed off and the colour fixed by a coating of varnish. This process is repeated time after time until the pattern is completed and the various colours desired have been introduced, after which one or two final coats of varnish completes the work. In some examples gold leaf is pressed into the partially dried varnish, which produces gold lacquer.

In Mandalay, and elsewhere in Upper Burma, the resin, after being thickened with rice husk or cow dung ashes, is used for moulding. The material is moulded between the fingers into the form of the bodies of animals, etc., and the details worked in with wooden modelling tools. This method is also used for the ornamentation of fancy boxes, idol thrones, portfolio covers, etc.

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Finally, there are the Burmese glass mosaics, or the art of wall decoration by coloured glasses imbedded in the specially prepared varnish. In many instances most elaborate designs have been traced on walls or around pillars, and as the material sets firmly it is very durable.

In conclusion, the author remarks that the varnish is of great merit and immense possibilities, and up to the present practically takes no part in the arts and industries of Europe and America.

Rate of Growth of a Seaweed.

The giant kelp, *Nereocystis luetkeana*, common on the shores of North-West America, sometimes reaches a length of 50 to 80 metres, and the rate of growth as recorded by T. C. Frye, in the *Botanical Gazette*, is as follows:—"The plant lives for two years; during the first year it attains a length of 1.25 to 2.5 m.; during the second year an average increase of 18 m. in length is made between the middle of March and the first of June, a period of about 70 days, which works out at an average of over 25 cm. a day, and about 0.175 mm. per minute."

This rate of growth is between one-third and one-fourth as rapid as that reported for the bamboo, and far above that of ordinary plants.

CHEMICAL.

By C. AINSWORTH MITCHELL, B.A. (Oxon.), F.I.C.

Upas Arrow Poison.

THE upas tree, *Antiaris toxicaria*, which grows in Borneo and other East Indian islands, has long had an evil reputation, and it is still a common belief that birds flying within the influence of its poisonous vapours instantly perish, and that it is fatal for animals or men to rest beneath its shade. As is the case with many another fable of natural history, there is some groundwork for the exaggerated reports of the evil effects of the upas tree, for it resembles certain *Rhus* plants in emitting a volatile substance which affects the skins of certain susceptible persons coming near it, though others are quite unaffected. There is no question, however, as to the poisonous nature of the sap of the tree, and it is the chief substance used by the Dyaks of Borneo for poisoning the tips of their darts. An interesting account of their method of preparing and using the poison has been given by Mr. John Allen to the Manchester Literary and Philosophical Society. An incision is made in the bark of the tree and the milky exudation collected on a palm leaf and dried first in the sun and then over a fire until a thick brown mass is left. In this state it can be kept without the poison deteriorating, and when required for use it is made into a thin paste with the juice of "tuba" root (which is used to stupefy fish), or with tobacco or lemon juice, and the ends of the darts dipped into the mixture and dried. These darts are made from the middle stem of the palm leaf and are about six or eight inches in length and of about the thickness of a knitting-needle. They are used with a wooden *sumpitan*, or blow-pipe, which is about seven or eight feet in length and has an internal diameter of about $\frac{1}{4}$ inch. A bird struck by one of these little darts is instantly killed, and a pig dies in about 20 minutes. The fresh juice of the upas tree, whether swallowed or injected into the blood, acts as a violent poison, causing convulsions and death from paralysis of the heart. It was shown some years ago by MM. Pelletier and Caventou that the active principle in the juice was a substance which they termed *antiarin*, $C_{14}\ H_{20}\ O_5$. It was crystalline and soluble in alcohol, and when heated with dilute acid was decomposed into glucose and a yellow resin. Another poison prepared from the roots of *Upas tieute*, a climbing plant, is in less common use as an arrow poison. Its action is still more deadly than that of *Upas antiaris*, and its effects resemble those produced by strychnine.

Early English Gunpowder.

A bucket containing bullets and gunpowder has been discovered in the roof of Durham Castle, where it is believed to have been walled up about the year 1641, when the castle was being prepared to withstand a Scottish raid. The bullets are moulded spheres of two sizes, and, according to the analyses of Messrs. Silberrad and Simpson, consist of a little over 99 per cent. of lead, with iron and silver and traces of bismuth, arsenic, and antimony. The gunpowder is not granulated like that of the present day, and was evidently prepared by simply mixing the ingredients. It contains about 1 per cent. of moisture, and the proportion of the constituents calculated on the dry powder is practically identical with that of the black gunpowder of to-day, viz., nitre, 75 per cent.; carbon, 15 per cent.; and sulphur, 10 per cent. It is pointed out by Messrs. Silberrad and Simpson that this is a remarkable fact, since the gunpowders made in England at that time contained a considerably larger amount of sulphur. The only gunpowder with the modern proportions in use in the 17th century was Prussian musket powder, and hence it is suggested that the Durham powder was probably of Prussian origin.

Calcium Hydride.

A new method of preparing calcium hydride, which will find its chief use in the production of hydrogen for balloons (see "KNOWLEDGE & SCIENTIFIC NEWS," this vol., p. 542), has been patented in this country. The metallic calcium is melted in an iron pot, and hydrogen conducted into it while it is in a state of fusion. The gas is absorbed rapidly, and the resulting product, which contains about 84 per cent. of pure calcium hydride, is cooled and broken into large lumps.

The Blue Colour of Water.

The intense blueness of the water in the reservoirs near Purley Station must have puzzled many who have looked down upon it from the adjacent downs, and have given rise to various guesses as to its cause. The real explanation, however, of the blue and green colours found in natural waters has been supplied by the experiments of M. Spring, of Liége. He finds that lime compounds impart no colour of their own, and are not the cause of the brilliant blues often seen in chalky waters, but that the colour is due to diffraction of the light by invisible particles still present in the water after the removal of all colouring matters. Yet the lime compounds play an active part in eliminating iron compounds and humic substances, which prevent the natural blue colour of the water from being seen. The fact that all calcareous waters are not blue is due to there sometimes being formed a state of equilibrium between the purifying action of the lime salts and the constant influx of humic and iron compounds, which mask the blue colour by their own brown tint.

GEOLOGICAL.

By EDWARD A. MARTIN, F.G.S.

Pliocene Beds in Iceland.

THERE is a fossiliferous deposit on the west coast of Tjornes, northern Iceland, which has been known to geologists for nearly 160 years. The molluscs found in it indicate a much milder climate than now, and the deposit was considered by Gwyn Jefferys and Searles Wood to be not younger than Middle Red Crag. Dr. H. Pjetursson now finds that at a height of above 500 feet above the sea, these beds are overlain by the "eastern basalts," being indurated and altered by them, and resting on some of the "older basalts." Thus there is an intercalation of a fossiliferous deposit of over 500 feet thick, occupying part of the great gap between tertiary and pleistocene rocks, whilst the latter contain indurated ground moraines. The oldest basalts of Iceland are thought to date from early tertiary times, and the occurrence of glacial deposits amongst the younger lavas, together with the fact that the island is still a centre of volcanic disturbance, furnish evidence of a remarkably protracted period of volcanic activity.

Trilobites from Bolivia.

Some interesting trilobites were obtained by Dr. J. W. Evans in Bolivia in 1901-1902, and these have been recently described by Mr. Philip Lake.

Several horizons are represented by these fossils. Two specimens of *Peltura*, probably from the Upper *Lingula-*

Flags, were collected at Cochaiya, about 3 miles north-east of Pata. New species of *Symphysurus* and *Trinucleus*, probably of Arenig age, were found about a mile from Apolo, Province of Caupolican. An indeterminable species of *Ogygia* was obtained from the right bank of the River Caca, in the same province. *Phacops* cf. *arbuteus*, *Dalmanites Paituna*, and *D. Maecurua* were collected in the track from Apolo to San José de Chupiamonas, also in the province of Caupolican. The nodules from which they were derived are probably of Lower Devonian age. It is worthy of remark that, while the earlier forms show affinities with the contemporaneous European fauna, the Devonian species are much more closely allied to those of South Africa and North America.

Vegetable Structures in Coral Reef.

Considerable interest is being shown in the light thrown upon the origin of limestone in the researches conducted by Messrs. Frederick Chapman and Douglas Mawson, in regard to the importance of *Halimeda* as a reef-forming organism. The freshwater *Chara*, calcareous algæ, nullipores, and purple sea-weeds of the type of *Lithothamnion* have long been known to form the basis of limestones and coral-reefs, but in *Halimeda* we have a calcareous green alga performing a similar operation. The material obtained in the great boring, the lagoon-borings, and lagoon-dredging at Funafuti has yielded a considerable quantity of *Halimeda*; and Dr. Guppy has described a *Halimeda*-limestone in the Solomon Islands. Evidence such as this shows that the important deposits of calcareous plant-remains forming at the present day can scarcely be paralleled by any deposit formed in past geological times, except, possibly, the limestones of the Alpine Trias, which owe their origin to the thallophytes *Diplopora* and *Gyroporella*. Among other *Halimeda*-limestones may be mentioned those of Christmas Island, Fiji, and Tonga, and the New Hebrides, but these differ considerably one from the other in the condition of preservation of their chief organic contents. *Halimeda* seems to be more liable to decay than *Lithothamnion*, corals, or foraminifera, and yet it appears to retain its structure to a considerable depth in reefs. Much of the fine powdery limestone associated with coral-reefs, and more especially with upraised coral-islands, may be primarily due to lagoon and other deposits formed by the agency of *Halimeda*.

ORNITHOLOGICAL.

By W. P. Pycraft, A.L.S., F.Z.S., M.B.O.U., &c

Herons and Fish Preservation.

Some little time since, the Dart District Fishery Board issued urgent appeals to the owners of heronries to reduce the number of their herons on account of the damage supposed to be done by their ravages.

The members of the Board do not seem to have been very well informed on the matter, as is usually the case. For the replies to their requests showed that at least one heronry existed only in the imagination of the Board, while another boasted but half-a-dozen birds, which the owner rightly refused to interfere with. As a matter of fact, the evidence all tended to show that the heron was by no means a common bird on the Dart.

We cannot but regret the fact that sport should so commonly go hand in hand with greediness. This stately bird is one of the few remaining relics of our native fauna which has been slowly strangled to ensure larger bags to the "sportsman." Happily, however, there are many who, while keen sportmen, are no less keen naturalists, and to them we owe what is left to us of our larger native birds and beasts.

Red Crested Pochard in Norfolk.

Mr. N. Herbert Smith, in the *Field*, September 15, records the fact that a pair of red-crested pochards (*Netta rufina*) were killed by his keeper at Hickling, on September 8. The first record of this bird as a British species dates back to 1818, when a female was killed on Breydon Water, in Norfolk, in the month of July. The present example made the tenth record for this county.

Nine other examples however, all males, have now to be added to this list. The Rev. M. C. H. Bird, recording the fact in the *Field*, September 22, that nine adults, six males and three females, of this species were killed on September 4, out of a flock of thirteen, on Breydon Water, Great Yarmouth. "Supposing," Mr. Bird writes, "as is probable, that the pair killed at Hickling on September 8 . . . were part of the above company, only one of the 'bakers' dozen' of these rare visitants remains unaccounted for." To this the editor of the *Field* pertinently remarks: "What a pity it is they should have to be 'accounted for,' instead of being left alone to delight hundreds of other people besides the shooter!"

Hoopoe in Cheshire.

Mr. Alfred Newstead records (*Field*, September 15) the fact that a hoopoe was captured near Chester on August 23, and remarks that this is only the third known instance of its occurrence in Cheshire.

Alpine Swift in Devon.

Two Alpine swifts (*Cypselus alpinus*) are reported (*Field*, September 22) to have been seen about a mile from Exmouth during August. The large size of these birds, and their very distinctive coloration, makes it unlikely that any mistake has occurred in the correctness of this record.

PHYSICAL.

By Alfred W. Porter, B.Sc.

Mechanical Analogue of a Diffraction Grating.

In the *Astrophysical Journal* for July Mr. H. M. Reese describes an experiment in illustration of the performance of diffraction gratings. "The scheme was to produce, on the surface of mercury, ripples emanating from a series of equidistant points distributed along a straight line." To produce these a thin sheet of iron was cut into the form of a comb of sixteen teeth, spaced 5 mm. apart, and attached to the lower prong of an electrically-driven tuning-fork arranged to vibrate in a vertical plane. This comb was set near the edge of a tray of mercury in such a way that the teeth would dip into the surface. When the ripples were examined stroboscopically it was seen that near the comb they mixed together chaotically; but at a moderate distance they resolved themselves into several series of regular rectilinear wave-trains, which advance in different directions and are symmetrically distributed. These correspond to the spectrum of zero order—moving out in a direction normal to the comb—and spectra of orders one and two on each side. An image of the ripples can be projected on a screen. To do this most successfully it must be arranged so that the projecting lens receives as much light as possible from the source. This is brought about if a converging beam from a lantern is incident upon the mercury and the projecting lens is placed at the point of convergence of this beam after reflection.

Distribution of Radiation from Radioactive Sources.

The sun appears as bright near the middle as near the edge; so does a round hot poker. This is a consequence of the cosine law, which states that the radiation from any very small element of the luminous body varies according to the cosine of the angle between the normal to the surface and the direction in which the element is viewed. The reason the element does not radiate equally in all directions is that the radiation comes not from the surface only, but from a perceptible depth; and in oblique directions the radiation suffers most loss from absorption by the layer of substance through which it passes. If it came only from the surface there is no reason why it should not spread out equally in all directions, and in that case the sun would not appear of uniform brightness. Prof. Rutherford has recently (*Philosophical Magazine*, August, 1906), explained in this way the peculiar appearance of the image formed by the alpha stream from radioactive bodies. A wire is made radioactive by exposure to radium emanation. The alpha radiation from it is allowed to pass in vacuo through a very narrow slit to a photographic plate, where it makes what is essentially a "pin-hole" photograph. Now the action on the

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plate is most intense near the edges of this image. This effect is attributed by Rutherford to the extreme thinness of the radioactive layer taken in conjunction with the fact that the alpha particles are, on an average, projected equally in all directions. Various corroborative experiments have been made. A brass rod of square cross section is made radioactive and examined either photographically or by its action upon a screen of willemite. If the screen is placed parallel to one of the faces of the rod the appearance is that of a feebly luminous band of about the same width as the rod, bordered on each side by a more luminous region. The central region is made luminous by only one side of the rod, while the outer regions are affected by two sides. When examined photographically the edges of the central band are very sharply defined without any gradual transition of intensity from one region to the other. Still more complicated appearances are obtained by the use of a rod of hexagonal section. A sudden change of intensity occurs at every point where the tangential radiation from another side of the rod adds its effect.

Formulae for Combinations of Lenses.

In a paper on lens testing read before the Optical Convention by Mr. T. H. Blakesley the following simple formulæ for lens combinations are given :—

1. If light passes through two lenses whose focal lengths are f_1, f_2 respectively, and the distance between the second principal focus of the first lens and the first principal focus of the second lens is K, *measured positively along the axis in the direction in which light is travelling*, then the resulting focal length of the combination is f_1^2/K.

2. The first principal focus of the combination is found by moving from the first principal focus of the first lens a distance f_1^2/K in a direction opposed to the direction of light.

3. A similar motion f_2^2/K takes place in the second principal focus, but in this case the motion, if positive, is down the stream of light.

4. If an object is in the first principal focus of a lens whose focal length is f_1 and a second lens whose focal length is f_2 is applied to the issuing light, *at any distance from the first lens*, the magnification of the resulting image is constant and its value is $-f_2/f_1$.

In applying these principles a thin concave lens has a *positive* focal length, a thin convex lens a *negative focal length*. The magnification is negative when the image is inverted. The lenses are supposed to be coaxial.

Although these formulæ follow at once from well-known principles, they are probably not as generally known as they deserve to be.

ZOOLOGICAL.

By R. Lydekker.

Winter Whitening of Hair.

As his observations have recently been called in question, it is interesting to note that Professor E. Metchnikoff, in a communication published in the *Comptes Rendus* of the Paris Academy for the present year (Vol. CXLII., pp. 1024, *et seq.*), reiterates the statement that the winter whitening of hairs (as well as feathers) is due to the action of a particular kind of phagocytes, or chromophagous cells, which remove the pigment from the interior of the hairs or feathers to the skin or to the surface. The theory that gas is the bleaching agent will, in the Professor's opinion, not hold good. Mr. Metchnikoff's observations have been made on the hair of the variable hare, and on the feathers of willow-grouse, ptarmigan, and of a hen, whose plumage began to turn white; and the chromophagous cells are stated to have been actually seen at work.

The Russian Tarpan.

In a communication published in the *Proceedings* of the Royal Society of Edinburgh, Professor Ewart expresses the opinion that the now extinct tarpan, or wild horse of the Russian steppes, was not a distinct species or race, but a hybrid produced from the mingling of the Mongolian wild horse with certain other ponies. He also ventures on the conjecture that the "Celtic pony" will probably prove more distinct from the horse than is either the zebra or the ass.

The Eye of the Mole-Rat.

If additional evidence in favour of the evolution of animals be necessary it would be afforded by the observations of an Hungarian anatomist, on the eye of the great mole-rat (*Spalax typhlus*) of Eastern Europe and Egypt, a creature which has the general habits of a mole, but is a strict vegetarian. Although the eye is completely buried beneath the skin (which probably permits the passage of a certain amount of light), and is thus functionless, yet all the essential structural features of that wonderful organ are present—only they never develop beyond the initial stages.

The Multiplication of Generic Names.

As an instance of the complexity now being introduced into zoological classification by advanced specialists, it may be noted that the well-known American naturalist, Mr. G. S. Miller, has recently proposed no less than twelve new genera of bats, all based on species which had previously been referred to other genera. The same writer is also of opinion that the Philippine flying-lemur, or colugo, should be separated generically from the ordinary Malay species. For the former, he adopts Gray's name, *Colugo*, while for the latter, on account of priority, he would employ the name *Cynocephalus* (long applied to the African baboons), for the familiar and time-honoured *Galeopithecus*. This change involves the replacement of the family name *Galeopithecidæ* by *Colugidæ*. It will be curious to see how naturalists, other than specialists, follow this lead.

The Habits of Elephant-Seals.

In an account of the zoological collections brought home from South Georgia, Dr. Einar Lönnberg gives some interesting particulars with regard to the habits of that gigantic animal, the elephant-seal, or sea-elephant. When disturbed by man, these monsters, if much irritated, raise themselves on the pelvic region, with the greater part of the body in an upright position, and at the same time inflate their nostrils, open their mouths, and roar hideously. At such times they are dangerous to approach directly in front, although they are at the same time so heavy and clumsy that an active man, if standing a little to one side, can escape their attack without much difficulty. Contrary to the general belief, they use only the fore-flippers when moving on land. Although the old males are generally silent, the young bulls keep up a constant howling during the spring, which has been compared to the barking of dogs.

Origin of Domesticated Fowls.

In *Spolia Zeylanica* for July (of which the Editor has been favoured with a copy) some interesting information is given with regard to hybridisation experiments between the Ceylon jungle-fowl and ordinary fowls. It is well known that such hybrids can be produced, but since in the one case at that time recorded such hybrids were infertile *inter se*, Darwin was led to exclude the wild Ceylon bird from the ancestry of domesticated fowls. In the new experiments, by mating hybrid cocks with domesticated hens, fertile eggs have been produced, as they also have by crossing a hybrid cock with a ¾ domestic hen. Hybrid cocks crossed with hybrid hens have, however, hitherto failed to produce fertile eggs.

REVIEWS OF BOOKS.

ASTRONOMY.

Royal Astronomical Society of Canada: Transactions for 1905, including selected papers and proceedings (Toronto, 1906, 209 pp.).—The contents of this volume, extracted from the year's work of an obviously vigorous and flourishing society, cover a wide range, from American-Indian stellar legends to the new Dominion Observatory at Ottawa and the latest Pacific cable, and from the astronomy of Tennyson to the figure of the sun. The disappointing eclipse expedition to Labrador is much in evidence, partly on account of elaborate experimental preparations for coronal

photography, and partly on account of the actual expedition and the geographical, magnetic and meteorological results which were beyond the reach of weather conditions. We can recommend both the volume and the Society as being worthy of a wider support than it has yet met with outside the limits of the Dominion.

BOTANY.

British Flowering Plants, by W. F. Kirby (Sidney Appleton: 1906).—We fear that both the beginner and the scientific botanist will find this book inadequate. It has one good feature, in describing the caterpillars which feed on various plants; and interesting scraps of plant lore are occasionally thrown in. But it is difficult to identify some of the figures. Scarce plants, such as *Geranium pyrenaicum* or *Rubus chamæmoras*, pose as typical of a genus; others, as *Cytisus capitatus*, *Tropa natans*, *Erica herbacea*, *Cerinthe major*, *Globularia vulgaris*, and *Oleaster*, are not found wild in the British Isles. There are also serious omissions. From a stroll in a Surrey lane we brought in *Melilot*, Ploughman's *Spikenard*, *Lysimachia vulgaris*, and *Torilis anthriscas*, neither of which could we find in this volume.

E. S. G.

GEOLOGY.

Annual Report of the Smithsonian Institution (Washington, Government Printing Office, 1906, 714 pp. and index).—The report which has just been issued brings the record of the "Operations, Expenditure, and Condition of the Institution" down to June 30, 1904. It is replete with information which is interesting to the whole scientific world. It is furnished with 208 illustrations, including geological specimens, sections, maps, and portraits. It is divided into two parts, the first dealing with matters referred to in the report of the Assistant Secretary of the Institution, and the second including papers describing and illustrating collections in the U.S. National Museum. Part I. gives an account which will be useful to young geologists, of the founding and history of the Institution. An Act of Congress founded it in 1846, and a museum was made one of its principal features. The first collection to come into its possession, was the valuable mineralogical cabinet bequeathed to it by John Smithson, who was himself a Fellow of the Royal Society of London. As years passed on it came to be regarded as the legitimate repository for national collections, and grants were made by Congress for its upkeep. Then in 1880, it was enacted that the collections made by the Coast and Interior Survey, the Geological Survey, and other Government bodies, should be permanently housed in what had come to be the National Museum. The Museum, we are told, contains objects whose intrinsic value mounts into the hundreds of thousands of dollars, many of which are so small that several could be carried away in a man's pocket, and, consequently, like all scientific institutions, it constantly needs an increased income and increased staff to protect its treasures. We must pass over the interesting reports by the Head Curators of the Departments of Anthropology, Biology, and Geology, and refer here to the Bibliography for 1903-1904. In this we have not only the titles of various publications issued, dealing with specimens in the Museum, but each has a brief, but sufficient *résumé* of important points. By far the greater portion of the volume is taken up with "Contributions to the History of American Geology," by George P. Merrill, the Head Curator of Geology. No less than 400 pages are devoted to historical narratives of the founders of geology in the States, as well as of others who are still living. In Great Britain we can scarcely imagine such a great service being done with Government aid in a Government publication, and it remained for Sir A. Geikie to do something in the same direction in his "Founders of Geology," without aid from the State. The names of all the best-known American geologists are to be found in this historical review, together with some account of the work of each, and in most cases a portrait, some of which are full-page, illustrates the text. This portion cannot fail to be of great benefit to current geology. The science has grown up around certain names, and some of them are best known by the errors which they committed. Herein lies the educational value of such a record, and the U.S. Government is doing a good work for future geologists in honouring past geologists by a permanent and official record of those whose work is done. Here we find details of the lives of many whose names are already familiar on this side of the ocean, and the accounts which are given now enable one to feel more in touch than ever with the pioneers of the science in the New World. Amongst those whose life-histories are given are Silliman, Eaton, Hitchcock, Mather, Owen, Dana, Dawson, Powell, and Logan, names as well known as any of our British geologists. In Appendix B, there are brief biographical sketches of the principal workers in American geology. This includes many whose work has been dealt with at greater length in a former part, but adds a large number of names of other geologists who have done, and are doing, good work. This part will be of great value for future reference. Three chapters deserve special mention, dealing respectively with the Footprints of the Connecticut Valley, the Eozoon Question, and the Laramie Question. These are of international importance, and are treated at length. The rise of the belief in the animal nature of the *Eozoon Canadense*, and its dramatic downfall, should be read by all who have a lingering belief in the foraminiferal nature of the remains. Possibly the matter would not have received the attention which the whole scientific world gave to it, if it had not been backed by such energetic men as Logan, its discoverer, and Dawson, the Canadian geologist, and Principal of McGill University, Montreal, for 38 years. From 1863, when Logan first announced his discovery, until 1894, when, as we are told, J. W. Gregory and H. J. Johnston-Lavis gave the "death-blow to the theory," warfare raged around the *Eozoon*. Dawson died in 1899, and it could have been but a few months before his death that he made, in person, a last appeal to the London Geological Society, and exhibited his specimens and lantern slides, illustrating the various points on which he depended for proving its animal nature. The appeal was, however, to a new and unsympathetic generation, to whom it had been satisfactorily proved that the structure was a purely mineralogical simulation of the organic. In summing up, we are told that "there is apparently no doubt but that this simulative form is due merely to a process of chemical metamorphism, a process of indefinite substitution and replacement, technically metasomatosis, acting upon rocks which are granular aggregates of lime-magnesian pyroxenes, with more or less calcareous matter, the serpentine being in all cases secondary. Similar structures have, moreover, been noted by various observers in rocks which were unmistakably of igneous origin." This conclusion should be noted in all geological text-books that still mention the *Eozoon*, although we think that this reputed creature might well now drop out entirely. The Laramie beds first examined by Hayden in 1854 and 1855, along the Upper Missouri River, have received almost as much discussion as that through which the *Eozoon* passed, although with more satisfactory results. The difficulty very early presented itself of deciding as between Cretaceous and Eocene. Cope, in 1874, said that in his opinion, there was "no alternative but to accept the results that a Tertiary flora was contemporaneous with a Cretaceous fauna, establishing an uninterrupted succession of life across what is generally regarded as one of the greatest breaks in geological time." And in 1897, Drs. Knowlton and Stanton came to the conclusion that "the base of the Laramie they would place immediately above the highest marine Cretaceous beds of the Rocky Mountains region," the top being marked by the Fort Union beds. The Fort Union beds are now, in fact, regarded as Eocene, and the lower-lying as Laramie Cretaceous.

E. A. M.

MISCELLANEOUS.

Carcinoma of the Rectum, by F. Swinford-Edwards, F.R.C.S. (Baillière, Tindall and Cox; price 2s. 6d. net).—Mr. Swinford-Edwards gives here his experience on the diagnosis and treatment of the above disease in words that should impress on his professional brethren the value of its early recognition and the necessity for prompt operative measures. In a few pages Mr. Edwards writes instructively on his subject, and presents it in a concise and up-to-date manner. Had the author illustrated his small work, it would, to our mind, have enhanced its value in the eyes of the student and practitioner.

XUM

MICROSCOPY

Conducted by F. SHILLINGTON SCALES, B.A., F.R.M.S.

The Staining of Blood Films.

THE *British Medical Journal* gives a summary of a comparative study by Alphonse Huisman of the value of different methods which have been recommended for the staining of blood films. He has tried seventeen different formulæ, following the directions given by their different authors, but finds that, with the exception of Jenner's stain, they do not readily yield good results, and often involve a long and complicated technique. With Jenner's method he is always able to obtain satisfactory preparations, but he thinks he can improve upon it by the introduction of certain modifications of his own. The stain he uses is a mixture of equal parts of a 1.175 per cent. solution of solid azure blue in absolute methyl alcohol and a 0.825 per cent. solution of pure eosin BA (Höchst) in the same medium. He stains for two minutes without previously fixing the film. By this method the nuclei appear a violet-blue, whilst the basophile protoplasm takes a light blue stain which gives a good differentiation from the rest of the preparation. The red corpuscles are rose-coloured. The neutrophile granules are rose-violet, violet, or violet-blue; basophile granules are blue, the metachromatic basophile granules are violet-red, and the oxyphile granules are red. The author also observes that some of the lymphocytes exhibit, when stained by this formula, evidence of a fine, blue, or metachromatic granulation.

Mounting Protozoa.

Very little attention is given in most text-books to methods of mounting Protozoa, either temporarily for the purpose of study or permanently. A brief account of some suitable methods, based on a contribution by Mr. C. W. Hargitt, may accordingly be of some service. With regard to living specimens, in the case of Amœba, or the more or less sedentary Protozoa, little precaution in the way of supporting the cover-glass, or rendering the specimens quiescent, is necessary. But for Paramœcium, Stylonichia, and others of similar activity, some method of restricting their movements is desirable. Narcotics, such as chloral hydrate, cocaine, and nicotine, or gelatinous substances, are apt to set up pathological conditions sooner or later. A few shreds of absorbent cotton under the cover-glass, so tangled as to greatly limit the movements, have proved very satisfactory, without interfering with the vitality of the specimens, and fresh water can be easily added without fear of losing the specimen.

Intra-vitam staining may be satisfactorily done with many of the Protozoa, and with many stains, especially methylene blue, methylene green, methylene violet, &c., in very dilute solutions. These stains are used to differentiate the organism during life, and must be watched throughout accordingly.

For killing and fixing, a rapid re-agent is necessary in order that the least possible distortion may result. This can be done by the method of irrigation under the cover-glass—the most difficult, but the least likely to lose the specimen—or by placing all the specimens bodily in the re-agent. Lang's fluid, used hot, applied to the edge of the cover-glass and drawn in with blotting paper applied to the other edge, is one of the most suitable fluids for the irrigation method. It must be removed by washing out with water in a similar way. The stains must be applied also, their excess removed, dehydration by alcohols of increasing strength will follow, and finally Canada balsam must be drawn in by similar methods.

Killing by heating over a lamp or burner, as is done with bacteria, is quite useless.

Perhaps the best method, when the supply of material permits of it, is to pipette the infusoria into a large watch-glass, carefully draw off the surplus fluid with a finer pipette, if necessary, under a microscope or lens, and to finish withdrawal of the last few drops by a thread syphon. The killing may be done by means of a saturated solution of mercury perchloride, to which has been added one per cent. acetic acid. This makes an excellent killing fluid, though weak chromic acid, 2 per cent. osmic acid, and potassium iodide have also their advocates. Formalin is generally rather unsatisfactory. Certain organisms, however, such as the Vorticellidæ, prove very difficult to kill in an expanded condition, and recourse must, therefore, be had to some narcotizing method, such as the gradual addition of chloral hydrate, &c.

When fixed, the organisms may be washed in water or dilute alcohol, as required, stained by one of the usual methods, dehydrated, cleared with cedar oil, clove oil, &c., and mounted in balsam. Glycerine or glycerine jelly, of course, requires a modified process. With each stage of the operations similar precautions must be adopted in transferring from one medium to another as were used in transferring from water to the killing medium. By the foregoing methods beautiful and permanent mounts may be made of Amœba, Paramœcium, Volvox, &c., in all their life stages.

Mounting Small Insects.

An excellent method for mounting small insects and Coleoptera was given some time ago by Mr. E. L. Fulmer as follows:—Drop the specimens into absolute alcohol and leave for an hour or more to dehydrate; then transfer to xylol or other clearing agent for a few minutes, and then mount direct in balsam. If it is desired to make opaque objects transparent, they should be boiled for a moment in caustic potash and then treated as above described. If it is desired to clear and mount small and fragile specimens with little handling, this may be accomplished by dropping them in water-free carbolic acid to kill, dehydrate, and clear. After remaining in this an hour or more they are mounted in balsam.

The smaller beetles, after being chloroformed, are often mounted directly in balsam. They are cloudy for a time when mounted in this manner, but in the course of four or five weeks they become clear, so that this simple method may be used to advantage with small insects and their parts if they are given time to clear up perfectly before being studied.

In working with scale-insects (Coccidæ), the insects are first picked out of the scales and placed upon a slide where it is desired to mount them. A few drops of a 5 per cent. solution of caustic potash are applied, and the specimens boiled in this for two or three minutes by holding the slide over a Bunsen burner. The specimens are then washed two or three times by being covered with a few drops of absolute alcohol, after which they are cleared and balsam applied.

XUM

Parallel Light in Photo-micrography.

An inquiry from a correspondent in Melbourne, Australia, raises a point in illumination for photo-micrography which puzzles many people and is worth my answering in detail. If a well-corrected stand condenser is adjusted so as to give parallel light, a well-corrected sub-stage condenser will then give an image of the source of illumination upon the screen, if the sub-stage condenser is focussed on the object on the slide and the objective correctly focussed likewise. Using the Nernst incandescent filament a narrow streak corresponding to the very narrow filament will be visable, whilst the edge of a lamp-wick would give a correspondingly broad streak. Any statements that are met with in text-books as to obtaining a fully-illuminated field with parallel light by this means are doubtless based on practical experience and are due to the fact that ordinary stand condensers are so ill-corrected that a perfect representation of the image is not obtainable. For visual work nothing better than this streak could be wished for; the streak image, ugly as it appears to the uninitiated, being the only really critical form of illumination for all critical work, for, after all, it is only a small part of the field that the worker is actually investigating, and for this he must have the utmost possible degree of resolution and definition. In photo-micrography, however, such a streak would be unpleasant, and, therefore, resolution must be sacrificed slightly for the sake of even illumination. To do this either the sub-stage condenser must be thrown very slightly out of focus, or the stand condenser must be re-adjusted. My own method is to use the stand condenser to focus the source of light in the air about eight inches from the sub-stage condenser, and in this position I place an iris diaphragm. The sub-stage condenser is then focussed on this iris diaphragm, and consequently on the image of the source of illumination. A very slight adjustment to the sub-stage condenser will then give me a bar of critical light, or enable me to fill the field uniformly, just as if I were focussing directly on the lamp. But it is only the very best sub-stage and stand condensers that will do this, and of the latter I know of no other condenser than Mr. Conrady's which is sufficiently well corrected.

Having adjusted the stand condenser for parallel light, on looking directly at it an image of the source of illumination will be seen because the eye itself is able to bring to a focus parallel rays. But if the condenser be unable to form truly parallel rays, it will be seen to be filled with light. That such parallel rays are not formed by ordinary condensers is readily demonstrated by endeavouring to adjust the stand condenser so that on bringing a sheet of paper nearer and removing it further the disc of light upon it remains of the same diameter, as it should do if the light were really parallel. The articles on photo-micrography which I contributed to these columns from November, 1905, to June, 1906, inclusive, will probably be found of service on this and similar points.

New Micro-chemical Tests for Wood.

The Journal of the Royal Microscopical Society gives the following summary of some new micro-chemical tests for wood, by V. Graefe. He adds to a solution of vanillin some drops of isobutyl-alcohol, and lets a little sulphuric acid (sp. gr. 1.84) run down the side of the test-tube. After heating, the mixture turns dark red, with a shade of blue. On diluting with alcohol and repeated additions of acid, it changes through blue-green to pale green. The author recommends as a standard re-agent the following :—30 c.cm. isobutyl-alcohol *plus* 15 c.cm. sulphuric acid. When wood-mash is treated with this re-agent the wood turns black; if now diluted with a little alcohol and the test-tube be shaken, the wood turns blue or blue-green, whilst the fluid becomes red-violet. Sections of ligneous tissue treated with this fluid are at first red-violet and after a time blue. The sections should remain in the re-agent for about an hour and then be mounted in glycerine. Apparently the stain is not very permanent. A mixture of isobutyl-alcohol and sulphuric acid also forms a useful re-agent. A drop of the mixture placed on a micro-section gradually turns it red, and if, after the lapse of about an hour, it be placed in glycerine it assumes a wine-red or red-violet hue.

Quekett Microscopical Club.

A series of demonstrations on the practical use of the microscope and its accessories has been arranged for the ensuing session. The first will be given by H. F. Angus on November 16, on "Axial Sub-stage Illumination," embracing the use of the plane and concave mirrors, sub-stage condensers, methods of centring the illuminant, and critical illumination. Subsequent demonstrations will deal with sub-stage non-axial illumination, including oblique, dark-ground, and multi-colour illumination, the employment of polarising apparatus, illumination of opaque objects, the use of various pieces of apparatus for recording observations, &c. Arrangements are not yet completed, but a full programme will be available shortly. The demonstrations will be given on the third Friday in each month from 7 till 8 p.m., and will not interfere with, but will be in addition to, the ordinary meetings of the Club, which are held at 20, Hanover Square, W., on the third Friday in each month at 8 p.m. precisely. Gentlemen interested are invited to communicate with the Hon. Sec., A. Earland, 31, Denmark Street, Watford, Herts.

Microscopical Lectures.

The Manchester Microscopical Society has sent me the prospectus of its Extension Lectures for the forthcoming winter, and I am glad to again call attention to so excellent a scheme. The prospectus contains a list of fifty-three lectures by various members of the Society on almost all subjects coming within the range of the microscope, many with titles no less attractive than the subjects of the lectures, and all illustrated by lantern slides, specimens, microscopes, or drawings. The object of the extension scheme, now in its ninth year, is, as the prospectus states, "to bring scientific knowledge, in a popular form, before societies who are unable to pay large fees to professional lecturers," and this is done without other charge than that of travelling expenses and hire of slides, save where lectures are given before societies which are commercial undertakings, or are subsidised from public grants. These lectures must be of great value in the populous working-class districts of Manchester and its neighbourhood, and reflect both credit and honour on the energetic society which is responsible for them, and, as I have said before, it would be well if other societies would follow so excellent an example. They would themselves benefit much by coming in contact with a wider public than that of their own membership.

[*Communications and Enquiries on Microscopical matters should be addressed to F. Shillington Scales, "Jersey," St. Barnabas Road, Cambridge.*]

XUM

The Face of the Sky for October.

By A. FOWLER, F.R.A.S., AND W. SHACKLETON, F.R.A.S.

THE SUN.—On the 1st the Sun rises at 6.0 and sets at 5.39; on the 31st he rises at 6.52 and sets at 4.36.

The position of the Sun's axis, centre of the disc, and heliographic longitude of the centre are given in the following table:—

Date.	Axis inclined from N. point.	Centre N. of Sun's Equator.	Heliographic Longitude of Centre of Disc.
Oct. 3 ..	26° 18′ E	6° 33′	244° 19′
,, 8 ..	26° 29′ E	6° 15′	178° 20′
,, 13 ..	26° 28′ E	5° 55′	113° 23′
,, 18 ..	26° 17′ E	5° 32′	46° 27′
,, 23 ..	25° 54′ E	5° 6′	340° 30′
,, 28 ..	25° 20′ E	4° 38′	274° 34′
Nov. 2 ..	24° 33′ E	4° 8′	208° 38′

THE MOON:—

Date.	Phases.	H. M.
Oct. 2 ..	○ Full Moon	0 48 p.m.
,, 10 ..	☾ Last Quarter	3 39 p.m.
,, 17 ..	● New Moon	10 43 p.m.
,, 24 ..	☽ First Quarter	1 50 p.m.
Nov. 1 ..	○ Full Moon	4 46 a.m.
Oct. 7 ..	Apogee	7 48 p.m.
,, 19 ..	Perigee	5 48 p.m.

OCCULTATIONS.—The following table gives particulars of the principal occultations visible before midnight at Greenwich, during the month:—

Date.	Star's Name.	Magnitude.	Disappearance.		Reappearance.	
			Mean Time.	Angle from N. point.	Mean Time.	Angle from N. point.
			p. m.		p. m.	
Oct. 2	26 Ceti	6·0	11 28	356°	12 0	308°
,, 5	B.D.+12° 473 ..	6·2	9 55	96°	10 55	220°
,, 6	B.D.+14° 657 ..	6·5	7 48	116°	8 28	211°
,, 23	B.A.C. 6671 ..	6·5	8 35	158°	8 49	183°
,, 25	ι Capricorni ..	4·3	6 49	348°	6 56	338°
,, 26	45 Aquarii ..	6·3	8 16	48°	9 29	266°

THE PLANETS.—Mercury (Oct. 1, R.A. $12^h\ 49^m$; Dec. S. 4° 24′; Oct. 31, R.A. $15^h\ 42^m$; Dec. S. 22° 7′) is an evening star throughout the month, but sets so soon after the Sun that he may be considered unobservable.

Venus (Oct. 1, R.A. $15^h\ 19^m$; Dec. S. 22° 32′; Oct. 31, R.A. $16^h\ 44^m$; Dec. S. 27° 48′) remains an evening star, but, in consequence of the great southerly declination can only be observed for a short time after sunset; the planet in fact sets about one hour after the sun throughout the month. The distance of the planet from the earth is rapidly diminishing, and the apparent diameter accordingly increases from 28″·4 on the 1st to 44″·8 on the 31st. The crescent phase is now presented to the observer, one-third of the disc being illuminated on the 15th. The greatest brilliancy of the planet as seen from the earth occurs on the 26th.

Mars (Oct. 1, R.A. $10^h\ 55^m$; Dec. N. 8° 11′; Oct. 31, R.A. $12^h\ 5^m$; Dec. N. 0° 47′) is a morning star rising about 3.30 a.m. throughout the month. With its small apparent diameter of about 4″, it is of little telescopic interest.

Jupiter (Oct. 1, R.A. $6^h\ 42^m$; Dec. N. 22° 50′; Oct. 31, R.A. $6^h\ 48^m$; Dec. N. 22° 47′) is coming into a more favourable position for observation, rising at 9.50 p.m. on the 1st, and at 7.58 p.m. on the 31st. The planet describes a short direct path between ε and ζ Geminorum until the 29th, when he is "stationary." The apparent diameter of the planet increases from 36″·0 to 39″·4 during the month.

Saturn (Oct. 1, R.A. $22^h\ 48^m$; Dec. S. 9° 51′; Oct. 31, R.A. $22^h\ 43^m$; Dec. S. 10° 18′) is favourably placed for observation in the evening, being on the meridian at 10.9 p.m. on the 1st, and at 8.7 p.m. on the 31st. The planet describes a short retrograde path a little to the South of λ Aquarii. The outer major and minor axes of the ring system are respectively 43″ and 4″·6, so that in small telescopes the ring appears almost as a straight line; the "disappearance" of the ring is due next year.

Uranus (Oct. 15, R.A. $18^h\ 21^m$; Dec. S. 23° 41′), remains in Sagittarius, but is not very favourably situated for observation, as it sets soon after 9 p.m. at the beginning of the month, and at about 7.30 p.m. at the end of the month.

Neptune (Oct. 15, R.A. $6^h\ 55^m$; Dec. N. 21° 57′), rises shortly after 9 p.m. and crosses the meridian at 5.19 a.m. at the middle of the month. The planet is about 1½ degrees North-West of ζ Geminorum, is in quadrature on the 6th, and stationary on the 16th.

METEORS.—The principal meteor showers during the month is that having its radiant point near ν Orionis, and hence known as the Orionids. The maximum is from the 18th to the 20th, and the meteors are described as swift with streaks. The radiant point is in R.A. 92° Dec. N. 15°.

Algol presents conveniently observable minima on the 3rd at 9.19 p.m., 23rd at 11.2 p.m., and 26th at 7.51 p.m.

TELESCOPIC OBJECTS:—

Double stars: γ Arietis $1^h\ 48^m$, N. 18° 48′, mags. 4·2, 4·4; separation 8″·8. Easy double, power 30; notable as being the first double star observed telescopically.

γ Andromedæ $1^h\ 58^m$, N. 41° 51′, mags. 2·1, 4·9, separation 10″·2. The brighter component is intensely yellow, whilst the other is greenish blue. The fainter star is remarkable for being a binary, the components of which are now less than 1″ apart.

NEBULÆ:—

Nebula in Andromeda, easily visible to the naked eye, and readily found by referring to the stars β and ν Andromedæ. Seen with a 3 or 4 inch telescope, it appears to be an extended oval, which is in reality composed of spiral streams of nebulous matter.

(32 M.) Nebula close to the great Andromeda nebula, and situated about 2° to the South. It is fairly round, and appears somewhat like a star out of focus.

(18 ♓.) Lies about the same distance north of the great Andromeda nebula that 32 M does south; it is faint, but large and elliptical.

XUM